ORIGINAL

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March 11, 2016

Docket Control
Arizona Corporation Commission
1200 W. Washington
Phoenix, AZ 85007

RE: Arizona Public Service Company 2015 DSM Annual Progress Report
Measurement, Evaluation, and Research (MER) Reports
Docket No. E-00000U-16-0069

In accordance with the Commission's Energy Efficiency Standard:

> A.A.C. R14-2-2415: An affected utility shall monitor and evaluate each DSM program and DSM measure. . .
>
> A.A.C. R14-2-2404(E): An affected utility may count toward meeting the standard up to one third of the energy savings, resulting from energy efficiency building codes that are quantified and reported through a measurement and evaluation study undertaken by the affected utility.

and Decision No. 73089:

> . . .up to one third of any energy savings quantified and reported through a measurement and evaluation study undertaken by Arizona Public Service Company, and resulting from improved energy efficiency appliance standards that Arizona Public Service Company counts toward meeting its Energy Efficiency Standard. . .

APS hereby files its MER Verification Report (Attachment A) and its Codes and Standards MER Report (Attachment B) for the DSM Program Year 2015. If you have any questions, please contact me at (602)250-3341.

Sincerely,

Kerri A. Carnes

KC/ks

cc: Candrea Allen
Brian Bozzo

Attachment A

NAVIGANT

APS MER Verification Report

Program Year 2015

Prepared for:

Arizona Public Service Company

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March 7, 2016

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Disclaimer

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Introduction

Navigant has completed a review and verification of the energy savings resulting from APS's Demand-Side Management (DSM) programs for calendar year 2015. This report contains the results from that verification, which can be summarized as follows:

- Navigant found that APS accurately applied Navigant verified savings in the work papers that support their 2015 Annual Progress Report.
- However, APS slightly overestimated the savings for the Solutions for Business Program resulting in realization rates of 99.8%. The realization rate for the APS portfolio overall is 99.9%. This results in a verified reduction of 354 MWh (0.06% of the total savings) for the portfolio for the entire year.
- Savings for the Solutions for Business Program should be decreased by 354 MWh to account for small tracking discrepancies that affected several measures, including: linear fluorescents, water-cooled chillers, programmable thermostats, anti-sweat heater controls, and LED exit signs.
- Navigant finds that the reported savings for the total portfolio of DSM programs for calendar year 2015 should be adjusted downward by 354 MWh, from 552,424 MWh reported in the supporting work papers to 552,069 MWh verified in this Savings Verification Report.

Verification of 2015 APS Reported Savings

Navigant verified that APS' reported energy savings for calendar year 2015 are consistent with evaluation results and recommendations provided as part of the annual MER process. Verification consisted of comparing measure level savings estimates from APS work papers[1] with recommended savings provided to APS by Navigant as part of the 2015 MER process. Specifically, Navigant reviewed APS savings estimates for consistency with a) baseline efficiency changes, b) program implementation modifications, c) new measures approved by the Arizona Corporation Commission for implementation in 2015[2], and d) any discrepancies between APS estimates and Navigant verified recommendations.

The results of Navigant's verification are presented in Table 1. The following describes the reported values in each column:

- Column A – Reported savings for 2015 program activity as outlined in APS work papers that support the Annual DSM Progress Report that was submitted on March 1, 2016.
- Column B - Reported savings for program activity occurring January through June 2015 as outlined in APS work papers.
- Column C - Reported savings for program activity occurring July through December 2015 as outlined in APS work papers.
- Column D - Navigant verified adjustments to APS work papers accounting for discrepancies between APS estimates and Navigant recommendations.
- Column E – Verified reported savings estimates for 2015 APS program activity based on Navigant verified findings and adjustments listed in Column D. Values are calculated by adding Column A and D.

[1] Work papers supporting end-of-year fillings with the Arizona Corporation Commission.

[2] The ACC approved new LED measures for the Home Performance with ENERGY STAR ® and Solutions for Business – Express Solutions programs, updated Builder Option Packages for the Multi-family Energy Efficiency Program, and participation in the Prepaid Energy Conservation Pilot Program.

- Column F – The realization rate – or ratio of verified to reported savings – used to quantify the accuracy of APS reporting (i.e. a value of 100% is the most accurate). The realization rate is calculated by dividing the verified estimate by the reported value (i.e. Column E/Column A).

The realization rate of nearly 100% for all programs demonstrates that APS accurately incorporated Navigant recommendations in the work papers that support the 2015 Annual Progress Report of annual energy savings at the generator. However, APS slightly overestimated annual savings for the Solutions for Business program, resulting in a realization rate of 99.8% for the Solutions for Business Program and a portfolio level realization rate of 99.9%. Through this process, Navigant validated that the 552,424 MWh savings claimed in the supporting work papers should be adjusted up by 354 MWh (0.06% of the total savings) to 552,069 MWh.

The Measurement, Evaluation and Research (MER) Process

Navigant conducts research concurrent with the implementation of energy efficiency programs by APS. This formal evaluation process provides research-based findings on the estimated savings for programs and measures in the APS portfolio of DSM programs. MER research findings are based on extensive measurement and verification activities including engineering analysis, field metering, on-site inspection, customer surveys, contractor and trade ally interviews, focus groups, billing records analyses, and review of implementation tracking databases and documentation. Through the MER process, Navigant provides ongoing evaluation to APS in separate measure-analysis spreadsheets, analytic databases, memos, reports, and presentations. The research provided to APS is used to:

- Assess and verify non-coincident demand savings, coincident demand savings, annual energy savings, and lifetime energy savings claimed by APS in the previous year. In doing so, the accuracy of program savings results are verified through detailed analysis and performance measurement of savings as reported in APS' annual filing with the Arizona Corporation Commission (ACC).
- Calculate cost-effectiveness at the program and portfolio level based on the Societal Cost Test (SCT).
- Drive planning for MER activities for the current program year.
- Refine savings and cost estimates at the program and measure level for the current program year. MER findings and recommendations inform APS savings claims, cost-effectiveness estimates, lost fixed cost recovery, and performance incentives for the current program year.
- Inform program planning savings and cost estimates to support APS implementation plan for the following program year.

Table 1. APS Reported and 2015 MER Report Verified Annual Energy Savings (MWh) and Realization Rates – January through December 2015

	APS Reported Savings			MER Verified Adjustments and Savings		
Program Name	(A) January-December (MWh)[3]	(B) January - June (MWh)	(C) July - December (MWh)	(D) 2015 Adjustments (MWh)[4]	(E) 2015 Verified (MWh)	(F) Realization Rate[5]
RESIDENTIAL PROGRAMS						
Consumer Products Program	110,744	57,221	53,523	0	110,744	100.0%
Residential Existing HVAC	18,232	6,423	11,808	0	18,232	100.0%
Home Performance with Energy Star	3,947	1,965	1,981	0	3,947	100.0%
Residential New Construction	11,257	4,957	6,300	0	11,257	100.0%
Appliance Recycling	8,374	4,132	4,242	0	8,374	100.0%
Residential Behavioral	57,444	28,722	28,722	0	57,444	100.0%
Multifamily	9,623	3,209	6,414	0	9,623	100.0%
Low Income	1,793	896	896	0	1,793	100.0%
Prepay	1,929	964	964	0	1,929	100.0%
Total Residential	***223,343***	***108,490***	***114,850***	***0***	***223,343***	***100.0%***
SOLUTIONS FOR BUSINESS PROGRAMS						
Large Existing	164,814	46,038	118,776	-156	164,658	99.9%
Small Business	14,867	6,633	8,233	-149	14,718	99.0%
New Construction	33,426	9,017	24,409	1	33,426	100.0%
Schools	12,925	5,848	7,077	-50	12,875	99.6%
Energy Information Services	31	7	24	0	31	100.0%
Total Solutions For Business	***226,063***	***67,543***	***158,519***	***-354***	***225,708***	***99.8%***
Total EE Programs	***449,406***	***176,034***	***273,369***	***-354***	***449,051***	***99.9%***
Codes & Standards	45,915	N/A	N/A	N/A	45,915	100.0%
System Savings	3,113	N/A	N/A	N/A	3,113	100.0%
DR Contribution	53,990	N/A	N/A	N/A	53,990	100.0%
DSM Total	**552,424**	**176,034**	**273,369**	**-354**	**552,069**	**99.9%**

Source: Navigant Analysis

[3] As reported in Annual Progress Report – March 2016.

[4] Adjustments account for changes and any discrepancies between APS estimates and Navigant recommendations.

[5] Realization Rate is calculated by dividing verified savings (Column E) by annual reported savings (Column A).

2015 Verification Findings by Program

Navigant's findings from the review of APS work papers are as follows:

- Consumer Products Program
  - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
  - APS accurately adjusted LED and CFL savings to account for new findings from a field study which found new operational hours and in-service rates.
  - APS accurately adjusted savings for variable speed pool pumps, based on a mix of manufacturer and pump sizes derived from the implementation tracking data.
- Residential Existing HVAC
  - APS accurately updated savings estimates for the Duct Test and Repair, Prescriptive Duct Repair, Quality Installation, and Advanced Diagnostic Tune Up measures for 2015.
  - APS accurately accounted for all baselines and although the federal minimum standard changed for equipment installed through the Quality Installation measure, savings won't be affected until mid-2016 due to an 18 month selloff period of old equipment.
- Residential New Construction
  - APS accurately accounted for more efficient baselines resulting from increased adoption of stringent building energy codes for single family homes for jurisdictions within APS service territory.
- Home Performance with Energy Star
  - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
  - Navigant recommends APS begin to claim savings in 2016, or as soon as possible, for behavioral tips provided through the Energy Analyzer offering of the Home Performance with Energy Star program. Savings from behavioral tips are not currently included in the savings presented in Table 1. In 2015, Navigant verified energy savings of 61 kWh per home (totaling 538 MWh in 2015) based on the frequency and type of tips presented to users and self-reported data regarding implementation of recommended energy efficient behaviors. Navigant provided design assistance for implementing data collection systems to inform future evaluation energy savings resulting from behavioral tips.
- Appliance Recycling
  - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
- Residential Behavioral
  - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
- Multi-Family Energy Efficiency Program
  - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
- Low Income Weatherization Program
  - This program is not evaluated as part of Navigant's MER contract. Values listed in the tables are based on APS reported savings.
- Pre-Pay
  - APS accurately reported savings for pre-pay pilot program participants based on an updated assessment of energy reductions due to service disconnects for a larger population of program participants.
- Solutions for Business Program
  - Navigant adjusted savings to correct for slight discrepancies in tracked values for a small number of measures, including: linear fluorescents, programmable thermostats, water-cooled chillers, occupancy sensors, low and medium temperature anti-sweat heater

controls, and LED exit signs. For example, Navigant adjusted deemed savings estimates for linear fluorescents to account for an updated baseline assumption in 2015 which had not been provided to the implementation contractor. The adjustments resulted in a realization rate of 73% for linear fluorescents.
    - Navigant found that APS correctly incorporated new deemed hours of operation for Express Solutions lighting measures that resulted from Navigant's 2014/2015 metering study.
    - The adjustments for all tracking discrepancies reduced the total reported Solutions for Business savings by 0.2%.
- Energy Information Services Program
    - APS accurately reported savings based on Navigant evaluation results and recommendations provided as part of the annual MER process.
- Codes and Standards Program
    - APS accurately accounted for tracking database adjustments for commercial new construction projects and incorporated savings due to new efficiency standards for residential air conditioners and heat pumps provided by Navigant during the evaluation process.
- System Savings
    - Navigant does not conduct evaluation activities for this program and therefore did not provide a verification of APS reported numbers. Values listed in the tables are consistent with APS reported savings.
- Demand Response Contribution
    - Navigant does not conduct evaluation activities for this program and therefore did not provide a verification of APS reported numbers. Values listed in the tables are consistent with APS reported savings.

Attachment B

NAVIGANT

APS Codes and Standards Report

Program Year 2015

Prepared for:

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Reference No.: 139948
February 18, 2016

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EXECUTIVE SUMMARY

This report presents Navigant's results and analysis of energy and demand savings resulting from improved energy efficiency appliance standards and building codes claimable by APS in 2015. As stated in section R14-2-2404 part E of the Electric Energy Efficiency Standards[1],

> *"An affected utility may count toward meeting the standard up to one third of the energy savings, resulting from energy efficiency building codes, that are quantified and reported through a measurement and evaluation study undertaken by the affected utility."*

Furthermore, the Arizona Corporation Commission (ACC) allows Arizona Public Service (APS) to include savings "resulting from improved energy efficiency appliance standards."[2] This report presents the results of Navigant Consulting, Inc.'s (Navigant's) evaluation of savings attributable to recent changes to building codes and appliance standards claimable by APS under these rulings.

The savings presented in this report reflect increased adoption of federal, state, and jurisdictional codes and standards (C&S) that are directly influenced by APS' portfolio of Demand Side Management (DSM) programs. This increased adoption results in more efficient baselines which, in addition to driving greater savings for C&S programs, reduces the savings potential for measures currently incentivized by APS' DSM programs. Therefore, each year APS adjusts their savings accordingly to reflect these baseline changes, which drives APS to pursue new program opportunities focused on the latest, most efficient technologies.

Table 1 presents the codes and standards related to the APS programs and measures discussed in this report.

Table 1. Code and Standard Updates in APS Territory

Measure/ End Use	Relevant APS Program	Relevant APS Measure	Old Code	New Code	Authority	Effective Year
General Service Lamps (GSLs)	Consumer Products	Compact Fluorescent Light Bulbs	None	EISA[3]	Federal	2012, 2013, 2014
Linear Fluorescent Lamps (LFLs)	Solutions for Business	Premium T8s and T5s	EPACT 1992	DOE Federal Rulemaking[4]	Federal	2012

[1] Docket No. RE-00000C-09-0427 (Electric Energy Efficiency Rules) Title 14, Chapter 2, Article 24, section R14-2-2404.
[2] Docket No. E-01345A-11-0232; Decision No. 73089 pg. 56 Line 11
[3] Energy Independence and Security Act of 2007. Public Law 110-140, 110th Congress. December 19, 2007. http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf
[4] U.S. Department of Energy. *"Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule."* July 14, 2009. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf

Measure/ End Use	Relevant APS Program	Relevant APS Measure	Old Code	New Code	Authority	Effective Year
Residential Air Conditioners and Heat Pumps	Residential HVAC	Residential Air Conditioners and Heat Pumps	DOE Federal Rulemaking[5]	DOE Federal Rulemaking[6]	Federal	2015
Motors	Solutions for Business	NEMA Premium Motors	EPACT 1992	EISA	Federal	2010
Residential New Construction	ENERGY STAR Homes	ENERGY STAR Version 3 Homes	IECC 2003, 2006, 2009	IECC 2006, 2009, 2012	Jurisdictional	Various
Commercial New Construction	Solutions for Business	Whole Building Design	ASHRAE 90.1 2007, 2010	ASHRAE 90.1 2010, 2013	Jurisdictional	Various

Source: Navigant analysis

Table 2 summarizes the C&S energy and demand savings claimable by APS for 2015. Navigant applied the ACC prescribed allowance of one-third to calculate C&S program savings for all codes and standards under consideration. Navigant calculated lifetime energy savings by multiplying the annual energy savings by the effective useful lifetime for each measure.

Table 2. Energy and Demand Savings at Generator[7] for 2015 Codes and Standards Program

Measure/End Use	Annual Energy Savings (MWh)	Lifetime Energy Savings (MWh)	Demand Savings (MW)
General Service Lamps	21,405	42,809	3.13
Linear Fluorescents	7,969	119,536	2.04
Residential Air Conditioners and Heat Pumps	2,899	52,189	1.5
Motors	2,248	33,724	0.78
Residential New Con	6,848	136,958	3.48
Commercial New Con	4,546	90,922	1.05
Total	45,915	476,138	**11.98**

Source: Navigant analysis

[5] U.S. Department of Energy. "*Energy Conservation Program for Consumer Products: Central Air Conditioners and Heat Pumps Energy Conservation Standards; Final Rule; technical correction.*" http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0089-0398

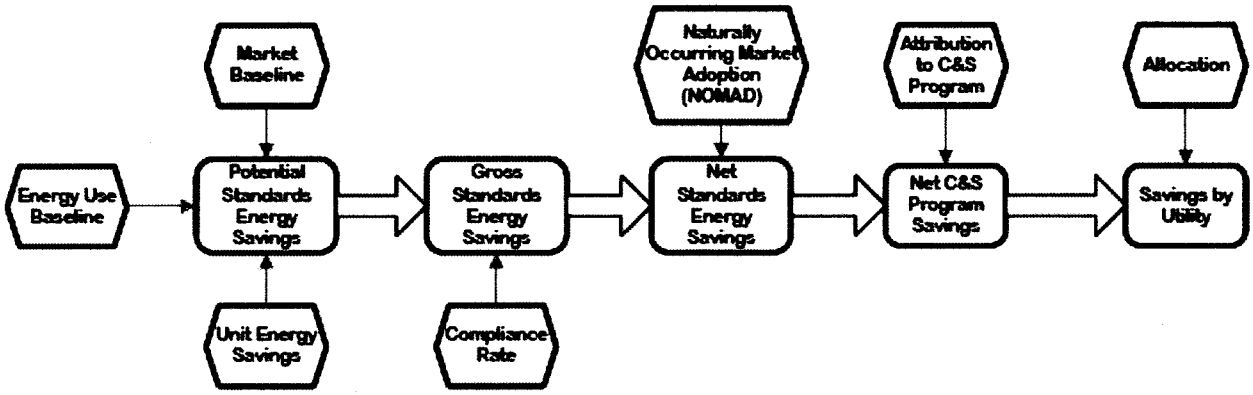
[6] U.S. Department of Energy. "*Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps; Direct Final Rule.*" http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0011-0001

[7] Generator savings are calculated using a line loss factor of 7% and 11.7% for energy and demand respectively, and a capacity reserve margin assumption of 15%.

Figure 1 shows an overview of the calculation methodology used to determine C&S savings. More detail on the methodology can be found in 6.5Appendix A. The remainder of this report uses this methodology as an outline for presenting the calculations and data sources used for each measure category. Each report section is divided into the following sections:

- *Description of the Code or Standard* – a qualitative description of the code or standard and how it affects energy use in APS territory
- *Potential Energy Savings* – the total energy savings from the code or standard change in APS territory, derived from market data and assuming 100 percent compliance
- *Gross Energy Savings* – potential energy savings adjusted for compliance rates
- *Net Energy Savings* – gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances or building practices
- *Net Codes and Standards Program Savings* – net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance

Figure 1. C&S Advocacy Program Evaluation Protocol



Source: 2008 ACEEE Summer Study on Energy Efficiency in Buildings[8]

[8] Lee, A. et al. *Utility Codes and Standards Programs: How Much Energy do they Save?* 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

1 GENERAL SERVICE LAMPS

This section describes the revised standard and methodology for calculating savings for general service lamps (GSLs). Table 3 summarizes the savings claimable by APS for GSLs.

Table 3. 2015 APS Net Energy and Demand Savings at Generator from the EISA GSL Standard

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	21,405
Net C&S Program Lifetime Energy Savings	42,809
Net C&S Program Demand Savings	3.13

Source: Navigant analysis

1.1 Description of the Standard

This section describes the new standard for GSLs that Navigant modeled.

The Energy Independence and Security Act[9] (EISA) passed in 2007, raised efficiency standards for general service lamps, requiring lamps to use approximately 25-30 percent less energy than typical incandescent bulbs.[10] The standard was effective in 2012, 2013, and 2014 for different lumen ranges, according to Table 4. The standard is technology neutral, so the prescribed maximum wattages can be met by compact fluorescent lamps (CFLs), light emitting diodes (LEDs), and some advanced incandescent bulbs (*e.g.*, halogens).

Table 4. EISA 2007 Prescribed Standards for General Service Incandescent Lamps

Rated Lumen Ranges	Maximum Rated Wattages	Minimum Rated Lifetime (hrs)	Effective Date
1490-2600	72	1000 hours	January 1, 2012
1050-1489	53	1000 hours	January 1, 2013
750-1049	43	1000 hours	January 1, 2014
310-749	29	1000 hours	January 1, 2014

Source: EISA 2007

1.2 Potential Energy Savings

This section discusses the potential energy savings for general service lamps. Potential energy savings are the total energy savings from the standard change in APS territory, derived from market data and assuming 100 percent compliance.

[9] Energy Independence and Security Act of 2007. Public Law 110-140, 110th Congress. http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm

[10] Appliance Standards Awareness Project. General Service Lamps. http://www.appliance-standards.org/node/6810

Navigant's calculation of the GSL potential energy savings represents a hypothetical scenario in which low-efficiency incandescent and halogen lamps covered under the standard are not sold after the effective date (full compliance). Navigant calculated potential energy savings using Equation 1. In 2015, all four lumen categories are affected by EISA standards, so the parenthetical term in Equation 1 produces four values. Total savings are the sum of these four values, plus the program influence adjustment. The inputs to Equation 1 are described in detail in the remainder of this section.

Equation 1. APS Territory-Wide Potential Energy Savings from the EISA GSL Standards (kWh)

$$\Sigma\left(\frac{((N_{IncNoEISA}-N_{IncEISA})\,x\,\frac{W}{bulb_{Inc}}+(N_{HalNoEISA}-N_{HalEISA})\,x\,\frac{W}{bulb_{Hal}})\,x\,(\%\,MShare_{lm})\,x\,(Factors_{sector})}{1000\,W/kW}\right)+Adjustment_{PI}$$

Where:

$N_{IncNoEISA}$	= Projection of the number of incandescent bulb sales in APS territory in 2015 absent EISA standards
$N_{IncEISA}$	= Projection of the number of incandescent bulb sales in APS territory in 2015 with EISA standards
$W/bulb_{Inc}$	= Watts per incandescent bulb in each lumen category
$N_{HalNoEISA}$	= Projection of the number of halogen bulb sales in APS territory in 2015 absent EISA standards
$N_{HalEISA}$	= Projection of the number of halogen bulb sales in APS territory in 2015 with EISA standards
$W/bulb_{Hal}$	= Watts per halogen bulb in each lumen category
$\%\,MShare_{lm}$	= The APS market share (in percent) of one of the four lumen categories
$Factors_{sector}$	= Technical factors such as the heating, ventilation, and air-conditioning (HVAC) interaction factor, line loss factor, coincidence factor, capacity reserve adjustment, coincidence factor, and hours of use
$Adjustment_{PI}$	= A savings adjustment (in kWh) to account for program influence or the fact that National Electric Manufacturers Association (NEMA) national sales data does not include CFL sales influenced by the APS incentive program

1.2.1 Unit Sales

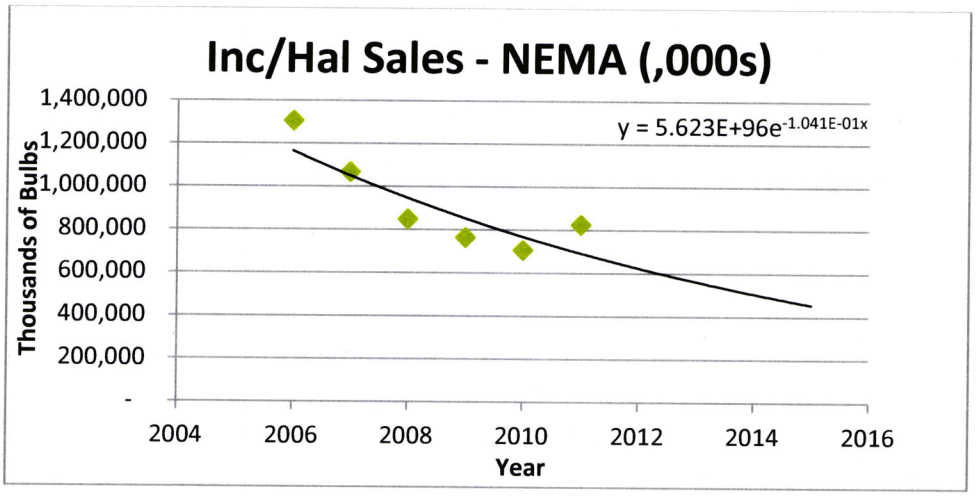
1.2.1.1 National Unit Sales

Using national sales data from the NEMA sales indices[11] and the U.S. Department of Energy (DOE) standards rulemaking process[12], Navigant fit an exponential function to the historic data (up until the effective date of the standard) to project combined national sales of incandescent and halogen bulbs for 2015 (Figure 2). Using this projection, Navigant estimates that the share of nationwide incandescent and halogen combined bulb sales reported by NEMA would be approximately 448 million bulbs in 2015.

[11] National Electric Manufacturers Association. "Incandescent Lamp Shipment Index." October, 2013 http://www.nema.org/news/Pages/Incandescent-Lamp-Shipments-Wane-During-Second-Quarter.aspx

[12] U.S. Department of Energy. "General Service Incandescent Lamps Rulemaking." http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/61

Figure 2. NEMA Nationwide Incandescent and Halogen Sales (Thousands of Bulbs)



Source: Navigant analysis

Manufacturer interviews conducted by Navigant indicate that NEMA sales data comprises 85 percent of the entire market for all bulbs in the U.S. Evaluations from California[13], Illinois[14] and Vermont[15], indicate that 90 percent of the shipments of general service lamps are destined for the residential sector, while 10 percent are installed in the commercial sector.

1.2.1.2 APS Unit Sales

Navigant applied adjustment factors to national bulb sales data to allocate national market data to APS territory-specific savings values. Navigant developed scaling factors for each relevant end-use sector (Table 5) using national, state, and APS 2015 electricity customer data from the Energy Information Administration[16]. Navigant applied these factors to the NEMA national sales data to estimate the share of bulbs distributed to customers in APS service territory (Table 6).

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[13] The CPUC's evaluation of the Statewide Upstream Lighting used store intercepts and on-site visits to estimate the percent of bulbs that go into nonresidential settings. Their findings yielded a 94%/6% residential/nonresidential split. Source: **Final Evaluation Report: Upstream Lighting Program**, *Volume 1*. KEMA. 2010. http://www.energydataweb.com/cpucFiles/18/FinalUpstreamLightingEvaluationReport_2.pdf

[14] ComEd's Plan Year 2 Residential ES Lighting program evaluation uses a 90%/10% residential/nonresidential split. Source: **Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010)** – *Evaluation Report: Residential Energy Star® Lighting*. Navigant Consulting, Inc. December, 2010. http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_Res_Lighting_PY2_Evaluation_Report_2010-12-21_Final.12113928.pdf

[15] "Vermont assumes currently that 10.5% of CFLs rebated via the buy-down program are installed in commercial facilities." Source: Personal communication. TJ Poor, Energy Programs Specialist. Vermont Department of Public Service. March 23, 2010."

[16] US Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. http://www.eia.gov/electricity/data/eia826/

Table 5. APS GSL Scaling Factors based on Electricity Customers by Sector

Scaling Factor	Residential	Commercial	Industrial
NEMA Shipments by Sector	90%	10%	0%
Scalar – U.S. to AZ[17]	2%	2%	1%
Scalar - AZ to APS[18]	39%	41%	56%

Source: Navigant analysis

Table 6. Calculated Quantity of Incandescent and Halogen Sales by Region

Region	Incandescent/Halogen Bulb Sales
National	527,578,625
Arizona	10,720,093
APS	4,193,186

Source: Navigant analysis

Navigant used the APS-incentive-program specific market share from historical program data, assuming it is reflective of the overall market for bulbs within APS service territory, to determine how much of the overall market is comprised of bulbs in each lumen category. This is presented in Table 7.

Table 7. Market Share by Lumen Category

Lumen Category	Incandescent Wattage Equivalent	Market Share
1490-2600	100 W	11%
1050-1489	75 W	16%
750-1049	60 W	67%
310-749	40 W	6%

Source: Navigant analysis

1.2.2 Unit Energy Consumption

Navigant used a national analysis of the EISA standard conducted by the Environmental Protection Agency (EPA)[19] to determine the market share of the incandescent (non-compliant) vs. halogen (compliant) bulbs. This analysis projects the average baseline bulb wattage (inclusive of compliant and non-compliant bulbs) for each lumen category between 2011 and 2014 (see Table 8). To determine a naturally occurring baseline without the standard, Navigant consulted internal lighting market experts to

[17] Based on Arizona's share of total U.S. electricity customers in each sector
[18] Based on APS's share of total Arizona electricity customers in each sector
[19] Environmental Protection Agency. *Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment.* http://www.energystar.gov/ia/partners/manuf_res/downloads/lighting/EPA_Report_on_NGL_Programs_for_508.pdf

estimate how the market would have progressed absent the EISA standard (see Table 9). Note that the average wattage per bulb is the same with and in the absence of EISA for certain lumen categories between 2011 and 2013 because each phase of the EISA standard affects different lumen categories in different years. The cells affected by the standard are highlighted in light brown. Navigant then calculated relative market shares for incandescent and halogen bulbs in each lumen bin such that the weighted average of the wattages presented in Table 10 resulted in the average wattages in Table 8 and Table 9. For example, in 2015 the market share of halogen lamps with EISA in the 1490-2600 lumen bin is 93% and the market share of incandescent lamps is 7%. Thus the average wattage is calculated as shown in Equation 2.

Equation 2. Weighted Average GSL Wattage Example for 1490-2600 Lumen Bin in 2015 with EISA

$$Weighted\ Average\ Wattage = (Market\ Share_{Incandescent} \times Wattage_{Incandescent}) + (Market\ Share_{Halogen} \times Wattage_{Halogen}) = (0.93\ x\ 72) + (.07\ x\ 100) = 74$$

Table 8. EPA Projections of Average Wattage per Bulb with EISA

Lumen Category	EISA Baseline (Average Watts per Bulb)				
	2011	2012	2013	2014	2015
1490-2600	97	90	80	76	74
1050-1489	73	72	64	58	56
750-1049	59	58	55	49	47
310-749	39	39	37	33	31

Source: EPA

Table 9. Navigant Projections of Average Wattage per Bulb without EISA

Lumen Category	No-EISA Baseline (Average Watts per Bulb)				
	2011	2012	2013	2014	2015
1490-2600	97	96	95	94	93
1050-1489	73	72	71	70	69
750-1049	59	58	55	54	53
310-749	39	39	37	36	35

Source: Navigant analysis

Table 10. Incandescent and Halogen Wattages

Lumen Category	Incandescent Wattage Equivalent	Halogen Wattage Equivalent
1490-2600	100 W	72 W
1050-1489	75 W	53 W
750-1049	60 W	43 W
310-749	40 W	29 W

Source: Navigant analysis

1.2.3 Program Influence Adjustment

Direct Consumer Products program savings from the sale of CFLs and LEDs are based on the adjusted baseline (with EISA influence) presented in Table 8. However, in absence of the APS program, the counterfactual baseline would be that presented in Table 9. Therefore, the introduction of the EISA standard provided a new, more efficient baseline, which reduced Consumer Products program savings. Because the NEMA sales data mentioned above only includes incandescent and halogen bulbs, and does not include the CFLs distributed through the program, the reduced program savings due to EISA needs to be included in the overall savings from the standard. According to analysis of program sales data, the EISA standard resulted in a reduction of 17,566,380 kWh in 2014 program savings and Navigant used that value as a proxy for 2015 program savings. These savings were added to the standard savings, as they are a direct result of the EISA standard.

1.2.4 Technical Factors

Energy savings calculations included the hours of use, line loss factors, and HVAC interaction factors listed in Table 11. Demand savings calculations included the hours of use, line loss factors, HVAC interaction factors, coincidence factors, and capacity reserve margin for both residential and commercial sectors and a diversity factor for the commercial sector listed in Table 11.

Table 11. Technical Factor Adjustments by Sector

Factor	Residential	Commercial
Hours of Use	807	3517
Line Loss Factor (Energy)	7.0%	7.0%
Line Loss Factor (Demand)	11.7%	11.7%
HVAC Interaction Factor (Energy)	0.10	0.16
HVAC Interaction Factor (Demand)	0.30	0.19
Coincidence Factor - APS	0.08	0.65
Diversity Factor - APS	1.0	0.78
Capacity Reserve Margin	15%	15%

Source: Navigant analysis

1.3 Gross Energy Savings

This section discusses the gross energy savings for general service lamps. Gross energy savings are the potential energy savings adjusted for compliance rates.

The Next Generation Lighting report developed by the EPA referenced above in Table 8 includes assumptions about compliance with the standard in the initial years of adoption. After reviewing the EPA analysis, Navigant did not apply any additional discounts for compliance rate for this analysis.

1.4 Net Energy Savings

This section discusses the net energy savings for general service lamps. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances.

Navigant's expert judgment of the counterfactual baseline absent the EISA standard is a reflection of the NOMAD of efficient appliances. As shown in Table 9, the NOMAD assumption is that the average wattage per bulb decreases by one watt per year absent EISA.

1.5 Net C&S Program Savings

This section discusses the net C&S program savings for general service lamps. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the effective useful lifetime (EUL) for the technology. Navigant applied an EUL of 2 years based on the expected lifetime of an EISA-compliant halogen bulb.[20]

Navigant calculated net annual and lifetime energy savings and net C&S program savings shown in Table 12 using the values and adjustments noted above in conjunction with Equation 1. The net C&S program savings are the final savings claimed by APS and include the one-third allowance adjustment. APS can claim 21,405 MWh of annual energy savings, 42,809 MWh of lifetime annual energy savings and 3.13 MW of demand savings from the federal EISA general service lamp standard.

Table 12. 2015 APS Net Energy and Demand Savings at Generator from the EISA GSL Standard

	kWh	MWh
Net Energy Savings – Residential	50,233,679	50,234
Net Energy Savings - Commercial	13,980,036	13,980
Total Net Energy Savings	64,213,715	64,214
Net C&S Program Energy Savings	**21,404,575**	**21,405**
Net C&S Program Lifetime Energy Savings	**42,809,143**	**42,809**
Net Demand Savings - Residential	6,892	6.89
Net Demand Savings - Commercial	2,482	2.48
Total Net Demand Savings	9,374	9.37
Net C&S Program Demand Savings	**3,125**	**3.13**

Source: Navigant analysis

[20] http://www.deeresources.com/

2 LINEAR FLUORESCENT LAMPS

This section describes the revised standard and methodology for calculating savings for linear fluorescent lamps. Table 13 summarizes the savings claimable by APS for linear fluorescent lamps.

Table 13. 2015 APS Net Energy and Demand Savings at Generator from the Linear Fluorescent Standard

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	7,969
Net C&S Program Lifetime Energy Savings	119,536
Net C&S Program Demand Savings	2.04

Source: Navigant analysis

2.1 Description of the Standard

This section describes the new standard for linear fluorescent lamps that Navigant modeled.

The first standards for linear fluorescent lamps were enacted by Congress in the Energy Policy Act of 1992 (EPACT). DOE updated the standards in 2009, with an effective date of July 14, 2012. Efficiency standards vary by type of lamp in terms of lumens per watt. For example, the standard for a 4-foot medium bipin with a color temperature of less than 4,500K (the most common lamp type) is 89 lumens per watt. In general, the new standard requires that T12 and 700 series T8 lamps be converted to the more efficient T8 lamps[21]. A summary of the energy conservation standards by bulb type is included in Table 14.

[21] The standards do not specify which lamp types must be manufactured but rather the efficacies that those lamps must achieve. The efficacy requirements are high enough that they effectively require the technologies described.

Table 14. Summary of the Amended Energy Conservation Standards for General Service Fluorescent Lamps[22]

Lamp Type	Correlated Color Temperature	Energy Conservation Standard (lm/W)
4-Foot Medium Bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-Foot U-Shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-Foot Slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-Foot High Output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-Foot Miniature Bipin Standard Output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-Foot Miniature Bipin High Output	≤4,500K	76
	>4,500K and ≤7,000K	72

Source: DOE

2.2 Potential Energy Savings

This section discusses the potential energy savings for linear fluorescent lamps. Potential energy savings are the total energy savings from the standard change in APS territory, derived from market data and assuming 100 percent compliance.

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which T12 linear fluorescents covered under the standard are not sold after the effective date and only premium T8s[23] are sold after the effective date (full compliance). Navigant calculated potential energy savings using the following equation:

[22] Department of Energy. "*Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.*" July 14, 2009. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf

[23] Premium T8s are efficient 800 series T8s that meet the 2012 DOE standards.

Equation 3. APS Territory-Wide Potential Energy Savings from the DOE Linear Fluorescent Standards (kWh)

$$\frac{(N_{avd\ T12} - Adjustment_{PI})\ x\ (W_{T12} - W_{T8\ Premium})\ x\ Factors_{sector}}{1000\ W/kW} + \frac{(N_{avd\ T8\ 700\ series})\ x\ (W_{T8\ 700\ series} - W_{T8\ Premium})\ x\ Factors_{sector}}{1000\ W/kW}$$

Where:

$N_{avd\ T12}$	= projection of the number of avoided T12 lamp sales in APS territory in 2015 (approximately 676,680 lamps)
$Adjustment_{PI}$	= An adjustment to the number of avoided T12 lamp sales to account for APS incentive program sales of T8, premium T8, and T5 lamps[24]
W_{T12}	= Average wattage per lamp for T12s being replaced by the standard, weighted by market share
$W_{T8\ Premium}$	= Average wattage per lamp for premium T8s that will replace T12s and 700 series T8s under the standard, weighted by market share
$Factors_{sector}$	= Technical factors such as the HVAC interaction factor, line loss factor, coincidence factor, capacity reserve adjustment, and hours of use
$N_{avd\ T8\ 700\ series}$	= projection of the number of avoided 700 series T8 lamp sales in APS territory in 2015
$W_{T8\ 700\ series}$	= Average wattage per lamp for 700 series T8s being replaced by the standard, weighted by market share (Table 17)

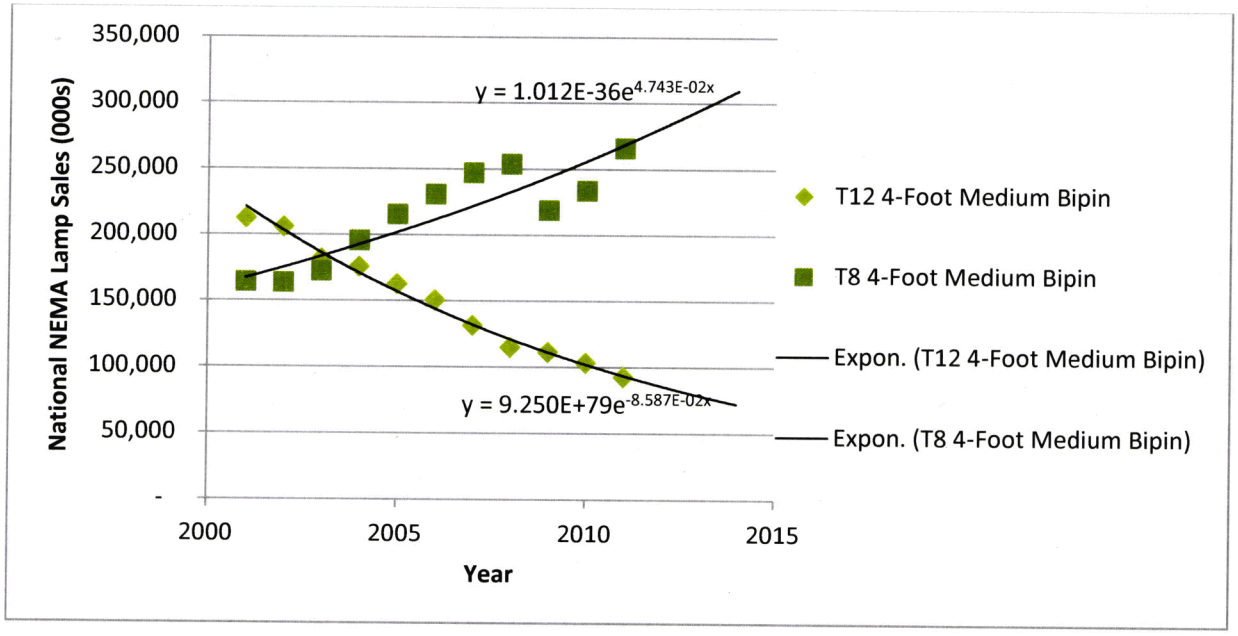
2.2.1 Unit Sales

2.2.1.1 National Unit Sales

Using national sales data from the NEMA sales indices[25] and the DOE standards rulemaking process[26], Navigant fit an exponential function to the historic data (up until the effective date of the standard) to project sales of T12 (non-compliant lamps) absent the standard for 2014 (Figure 3). These projections represent the avoided sales of T12 lamps, or sales that would have occurred, absent the standard. In other words, in the presence of the standard, with full compliance, we assume that all of these T12 sales are replaced by T8 sales. Using this projection, Navigant estimates that the NEMA T12 sales would have been approximately 66,223,847 lamps in 2015. These projections also represent the sales of T8 lamps. Navigant estimates that the NEMA T8 sales would be approximately 323,947,577 in 2015. Navigant then used DOE data to determine the market share of T8 lamps that are 700 series and 800 series.

[24] The purpose of the adjustment is to avoid double counting between incentive program and C&S program savings.
[25] National Electric Manufacturers Association. "T5/T8/T12 Lamp Shipment Index." http://www.nema.org/intelligence/pages/lamp-indices.aspx
[26] U.S. Department of Energy. "General Service Fluorescent Lamps Rulemaking." http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70

Figure 3. NEMA Nationwide T12 and T8 Lamp Sales (Thousands of Lamps)



Source: Navigant analysis

According to DOE, NEMA sales data comprises 90 percent of the entire market for all lamps in the U.S. NEMA data also indicates that 80 percent of the shipments of linear fluorescent lamps are destined for the commercial sector, while 20 percent are installed in the residential sector.

2.2.1.2 APS Unit Sales

Navigant applied adjustment factors to the national lamp sales data to allocate national market data to APS territory-specific savings values. Using national, state, and APS 2015 electricity sales data from the Energy Information Administration[27], Navigant developed scaling factors for each relevant end-use sector based on Arizona state and APS sales as a percent of total national electricity sales (Table 15). Navigant applied these factors to the national sales data to estimate the share of bulbs distributed to customers in APS service territory.

Table 15. APS Linear Fluorescent Scaling Factors based on Electricity Sales by Sector

Scaling Factor	Residential	Commercial	Industrial
NEMA Shipments by Sector	20%	80%	0%
Scalar – U.S. to AZ[28]	2%	2%	2%
Scalar - AZ to APS[29]	40%	43%	16%

Source: Navigant analysis

[27] U.S. Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. http://www.eia.gov/electricity/data/eia826/

[28] Based on Arizona's share of total U.S. electricity sales in each sector

[29] Based on APS's share of total Arizona electricity sales in each sector

Table 16. 2015 Estimated Quantity of Avoided T12 Sales and T8 Sales by Region

Region	T12 Bulb Sales	T8 Bulb Sales
National	73,582,052	359,941,753
Arizona	1,607,062	7,861,274
APS	676,680	3,310,118
APS (adjusted)	517,675	3,310,118

Source: Navigant analysis

2.2.2 Unit Energy Consumption

Using data provided by DOE[30], Navigant determined wattages of various lamp and ballast combinations. T12 and 700 series T8 lamps represent the baseline prior to the standard change (W_{T12} and $W_{T8\ 700\ series}$) and premium T8 lamps represent the baseline after the standard change ($W_{T8\ Premium}$). Navigant calculated a weighted average wattage for each lamp (Table 17) based on national market share estimates. See Appendix B for the DOE wattage and market share data. Hours of use estimates are from field metering of residential and commercial buildings in APS service territory and are noted in the APS Technical Reference Manual[31].

Table 17. 2015 Weighted Average Energy Consumption by Sector and Lamp Type

Calculation	Commercial	Residential
Weighted Average T12 Wattage (W_{T12})	35.9	22.9
Weighted Average 700 series T8 Wattage ($W_{T8\ 700\ series}$)	28.1	18.2
Weighted Average Premium T8 Wattage ($W_{T8\ Premium}$)	26.9	17.5
Hours of Use per Year	3005	876
Average Annual Energy Savings from T12 Conversion (kWh/lamp)	27	5
Average Annual Energy Savings from Basic T8 Conversion (kWh/lamp)	4	1

Source: Navigant analysis

2.2.3 Program Influence Adjustment

APS administers both a prescriptive rebate and direct install program (Express Solutions) under their Solutions for Business (S4B) program, which provide incentives to customers for replacing T12 lamps with High Performance T8[32] and Premium T8[33] lamps. Both programs claim verified savings from these lamp replacements. To avoid double-counting of savings directly claimed under the S4B program,

[30] Department of Energy. "*Final Rule Technical Support Document: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps*". July 2009. http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0131-0147

[31] Arizona Public Service. "Technical Reference Manual for APS Energy Efficiency Programs." Program Year 2013. Docket No. E-01345A-11-0224.

[32] http://library.cee1.org/content/cee-high-performance-t8-specification/

[33] http://library.cee1.org/content/reduced-wattage-t8-specification

Navigant subtracted the 159,005 lamps projected[34] to be installed due to the APS 2015 incentive programs from the 676,680 lamps of avoided sales in APS territory to calculate the adjusted avoided sales in Table 16.

2.2.4 Technical Factors

Energy savings calculations included hours of use, line loss factors, and HVAC interaction factors, listed in Table 18. Demand savings calculations included hours of use, line loss factors, HVAC interaction factors, coincidence factors, and capacity reserve margins listed in Table 18.

Table 18. Technical Factor Adjustments by Sector

Factor	Commercial	Residential
Hours of Use	3005	876
Line Loss Factor (Energy)	7.0%	7.0%
Line Loss Factor (Demand)	11.7%	11.7%
HVAC Interaction Factor (Energy)	0.14	0.10
HVAC Interaction Factor (Demand)	0.15	0.30
Coincidence Factor - APS	0.65	0.06
Capacity Reserve Margin	15%	15%

Source: Navigant analysis

2.3 Gross Energy Savings

This section discusses the gross energy savings for linear fluorescent lamps. Gross energy savings are the potential energy savings adjusted for compliance rates.

Navigant consulted internal lighting market experts to estimate a compliance rate with the standard. In 2012, the compliance rate is low because the standard became effective in July of that year. Navigant assumed that compliance rates increased to 90 percent in 2014. The compliance rate signifies that 90 percent of T12s in the market are shifted to T8s and 90 percent of 700 series T8s are shifted to premium T8s in 2014. The assumption is that 10 percent do not shift either due to a) exemptions in the definition of applicable fluorescent lamps, or b) the expected time for manufacturer stockpiles to diminish. In 2015, a 90 percent compliance rate is effectively full compliance, under the assumption that 10 percent of lamps are exempt from the standard. For the 2015 analysis, gross energy savings are calculated as 90 percent of potential energy savings. Navigant's assumptions for compliance rate are presented in Table 19.

[34] Navigant assumed the incentive program sales in 2015 were the same as those projected in 2014.

Table 19. Linear Fluorescent Standard Compliance Rate Assumptions by Year

Year	Compliance Rate
2012	25%
2013	75%
2014	90%
2015	90%

Source: Navigant analysis

2.4 Net Energy Savings

This section discusses the net energy savings for linear fluorescent lamps. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances.

Navigant's projection of the counterfactual baseline absent the linear fluorescent standard is a reflection of the NOMAD of efficient lamps. As shown in Figure 3, the exponential function used to project sales of T12 and T8s from 2012-2015 represents the natural trend present in the market before the effects of the standard.

2.5 Net C&S Program Savings

This section discusses the net C&S program savings for linear fluorescent lamps. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the effective useful lifetime for the technology. Navigant applied an EUL of 15 years, consistent with its characterization for linear fluorescents rebated through the APS Solutions for Business Program, and sourced from DEER 2008[35].

Navigant calculated net annual and lifetime energy and demand savings, and net C&S program savings shown in Table 20 using the values and adjustments noted above in conjunction with Equation 3. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 7,969 MWh of annual energy savings, 119,536 MWh of lifetime annual energy savings and 2.04 MW of demand savings from the federal linear fluorescent standard.

[35] http://www.deeresources.com/

Table 20. 2015 APS Net Energy and Demand Savings at Generator from the Federal Linear Fluorescent Standard

	kWh	MWh
Net Energy Savings – Residential	1,082,076	1,082
Net Energy Savings – Commercial	22,825,189	22,825
Total Net Energy Savings	23,907,264	23,907
Net C&S Program Energy Savings	**7,969,088**	**7,969**
Net C&S Program Lifetime Energy Savings	**119,536,322**	**119,536**
	kW	
Net Demand Savings – Residential	105	0.10
Net Demand Savings – Commercial	6,015	6.02
Total Net Demand Savings	6,120	6.12
Net C&S Program Demand Savings	**2,040**	**2.04**

Source: Navigant analysis

3 RESIDENTIAL AIR CONDITIONERS AND HEAT PUMPS

This section describes the revised standard and methodology for calculating savings for residential air conditioners and heat pumps. Table 21 summarizes the savings claimable by APS for residential air conditioners and heat pumps.

Table 21. 2015 APS Net Energy and Demand Savings at Generator from the Residential Air Conditioners and Heat Pumps Standard

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	2,899
Net C&S Program Lifetime Energy Savings	52,189
Net C&S Program Demand Savings	1.5

Source: Navigant analysis

3.1 Description of the Standard

This section describes the new standard for residential air conditioners and heat pumps that Navigant modeled.

Amendments to the Energy Policy and Conservation Act of 1975 (EPCA) in the National Appliance Energy Conservation Act of 1987 established EPCA's original energy conservation standards for central air conditioners and heat pumps. DOE subsequently updated the standards; the amended standards were effective in 2006. DOE again amended the standards in 2011, with an effective date of January 1st, 2015. Efficiency standards vary by state. Table 22 is a summary of the energy conservation standards for Arizona.

Table 22. Summary of the Amended Energy Conservation Standards for Residential Air Conditioners and Heat Pumps[36]

Product Class	Seasonal Energy Efficiency Ratio (SEER)	Heating Seasonal Performance Factor (HSPF)	Energy Efficiency Ratio (EER)	Average Off Mode Power Consumption $P_{W,OFF}$ (Watts)
Split-system air conditioners rated cooling capacity less than 45,000 Btu/hr	14	-	12.2	30
Split-system air conditioners rated cooling capacity equal to or greater than 45,000 Btu/hr	14	-	11.7	30
Split-system heat pumps	14	8.2		33
Single-package air conditioners	14	-	11.0	30
Single-package heat pumps	14	8.0	-	33
Small-duct, high-velocity systems	12	7.2	-	30
Space-constrained products – air conditioners	12	-	-	30
Space-constrained products – heat pumps	12	7.4	-	33

Source: DOE

DOE considered the last three product classes to include niche products and thus did not directly analyze them. Therefore, Navigant did not analyze them either.

3.2 Potential Energy Savings

This section discusses the potential energy savings for residential air conditioners and heat pumps. Potential energy savings are the total energy savings from the standard change in APS territory, derived from market data and assuming 100 percent compliance.

Navigant's calculation of the potential energy savings is based on a distribution of unit sales across various efficiencies before and after the standards take effect. Navigant calculated potential energy savings using the following formula:

Equation 4. APS Territory-Wide Potential Energy Savings from the DOE Residential Air Conditioner and Heat Pump Standards (kWh)

$$\sum_{SEER} ((N_{SEER\ Pre-Standard} - N_{SEER\ Post-Standard}) \times UEC_{SEER}) \times Factors_{sector}$$

Where:

$N_{SEER\ Pre-Standard}$ = Number of unit sales at each SEER level in APS territory in 2015 before the standard took effect

[36] Department of Energy. "*Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps; Direct final rule.*" June 27, 2011. http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0011-0001

$N_{SEER\ Post-Standard}$ = Number of unit sales at each SEER level in APS territory in 2015 after the standard took effect)
UEC_{SEER} = Unit energy consumption at each SEER level
$Factors_{sector}$ = Technical factors such as the line loss factor, capacity reserve margin, and coincidence factor.

3.2.1 Unit Sales

Navigant used national unit sales data and the percentage market share in each sector from the DOE standards rulemaking analysis[37] as the primary data source to determine the quantity of unit sales at each SEER level. Navigant then determined the percentage of national unit sales that are in hot-dry climate portion of the U.S. (the Western states), which includes Arizona. Using 2015 electricity sales data for the hot-dry states and APS service territory from the Energy Information Administration[38], Navigant developed scaling factors for each relevant end-use sector based on APS electricity sales as a percent of total hot-dry state electricity sales (Table 23).

Table 23. APS Residential Air Conditioners and Heat Pumps Scaling Factors based on Electricity Sales by Sector

Scaling Factor	Residential	Commercial	Industrial
National Unit Shipments by Sector	93%	7%	0%
Scalar – U.S. to Hot-Dry States[39]	8%	9%	12%
Scalar – Hot-Dry States to APS[40]	11%	11%	2%

Source: Navigant analysis

Table 24. 2015 Estimated Quantity of Residential Air Conditioners and Heat Pumps Unit Sales by Region

Region	Air Conditioner Sales	Heat Pump Sales
National	4,981,037	2,230,565
Hot-Dry States	863,158	256,827
APS	94,513	28,121

Source: Navigant analysis

3.2.2 Unit Energy Consumption

Navigant calculated the UEC for each SEER level based on a UEC per ton value and the average size (in tons) of residential air conditioner and heat pump systems in APS service territory. Navigant calculated UEC per ton based on an empirical model calibrated to data collected from an APS-specific metering

[37] U.S. Department of Energy. "General Service Fluorescent Lamps Rulemaking." http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70
[38] U.S. Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. http://www.eia.gov/electricity/data/eia826/
[39] Based on Arizona's share of total U.S. electricity sales in each sector
[40] Based on APS's share of total Arizona electricity sales in each sector

study of HVAC units. This model calculates annual energy consumption based on SEER and EER values of a particular HVAC unit. Navigant then multiplied the UEC per ton values by the average tons per unit sourced from APS program data for the Quality Installation rebate to determine the UEC per system. Navigant used energy simulation models from the 2014 evaluation of the Home Performance with Energy Star Program to compare consumption differences between air conditioners and heat pumps in Phoenix. From this comparison, Navigant determined an adjustment factor to derive heat pump UEC from air conditioner UEC.

3.2.3 Technical Factors

Energy savings calculations included the line loss factors listed in Table 25. Demand savings calculations included the line loss factors, coincidence factors, and capacity reserve margins listed in Table 25.

Table 25. Technical Factor Adjustments by Sector

Factor	Commercial	Residential
Line Loss Factor (Energy)	7.0%	7.0%
Line Loss Factor (Demand)	11.7%	11.7%
Coincidence Factor - APS	0.88	1.0
Capacity Reserve Margin	15%	15%

Source: Navigant analysis

3.3 Gross Energy Savings

This section discusses the gross energy savings for residential air conditioners and heat pumps. Gross energy savings are the potential energy savings adjusted for compliance rates.

In fall 2015, Navigant conducted surveys of HVAC distributors and contractors in APS territory to estimate a compliance rate with the standard. DOE allows for an 18 month grace period during which "legacy" split system and single package central air conditioners manufactured before January 1, 2015 may still be sold and installed in Arizona until July 1, 2016. Survey results indicated that this grace period resulted in partial compliance with the amended standard. During the grace period, interviewees indicated that the compliance rate was about 40%, with full compliance starting at the end of the grace period. Thus, Navigant applied a 40% compliance rate in 2015.

3.4 Net Energy Savings

This section discusses the net energy savings for residential air conditioners and heat pumps. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances.

DOE's projection of the counterfactual baseline absent the standard is a reflection of the NOMAD of efficient units. Consequently, net energy savings is equal to gross energy savings in this analysis.

3.5 Net C&S Program Savings

This section discusses the net C&S program savings for residential air conditioners and heat pumps. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the effective useful lifetime for the technology. Navigant applied an EUL of 18 years.

Navigant calculated net annual and lifetime energy and demand savings, and net C&S program savings shown in Table 26 using the values and adjustments noted above in conjunction with Equation 4. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 2,899 MWh of annual energy savings, 52,189 MWh of lifetime annual energy savings and 1.5 MW of demand savings from the federal residential air conditioners and heat pumps standard.

Table 26. 2015 APS Net Energy and Demand Savings at Generator from the Federal Residential Air Conditioners and Heat Pumps Standard

	kWh	MWh
Net Energy Savings – Residential	7,428,884	7,429
Net Energy Savings – Commercial	1,269,288	1,269
Total Net Energy Savings	8,698,172	8,698
Net C&S Program Energy Savings	**2,899,391**	**2,899**
Net C&S Program Lifetime Energy Savings	**52,189,030**	**52,189**
	kW	**MW**
Net Demand Savings – Residential	3,982	3.9
Net Demand Savings – Commercial	403	0.4
Total Net Demand Savings	4,385	4.4
Net C&S Program Demand Savings	**1,462**	**1.5**

Source: Navigant analysis

4. MOTORS

This section describes the revised standard and methodology for calculating savings. Table 27 summarizes the savings claimable by APS for motors.

Table 27. 2015 APS Net Energy and Demand Savings at Generator from the Motors Standard

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	2,248
Net C&S Program Lifetime Energy Savings	33,724
Net C&S Program Demand Savings	0.78

Source: Navigant analysis

4.1 Description of the Standard

This section describes the new standard for motors that Navigant modeled.

The first standards for electric motors were enacted by Congress in EPACT. EISA, passed by Congress in 2007, amended EPACT electric motor standards and expanded the scope of covered motors. Navigant's savings analysis is based on the difference between previous EPACT efficiencies and the new EISA requirements. Effective December 2010, the EISA standard requires that general purpose electric motors (subtype I) meet "NEMA Premium" efficiency levels and that general purpose electric motors (subtype II), fire pump motors, and NEMA Design B general purpose electric motors meet "NEMA Energy Efficient" levels. "NEMA Premium" motors are more efficient than "NEMA Energy Efficient" motors.

For this analysis, Navigant adopted the same methodology used by DOE for their National Impact Analysis of the effects of the standard.

4.2 Potential Energy Savings

This section discusses the potential energy savings for motors. Potential energy savings are the total energy savings from the standard change in APS territory, derived from market data and assuming 100 percent compliance.

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which all electric motors sold after the effective date are in compliance with the new standard (full compliance). Navigant calculated potential energy savings using Equation 5:

Equation 5. APS-Territory-Wide Potential Energy Savings from the EISA Electric Motors Standards (kWh)

$$\sum_{HP}((UEC_{Pre-Standard} - UEC_{Post-Standard}) \times N_{Motors\ HP} \times \%\ MShare_{HP}) \times Factors_{sector}$$

Where:

$UEC_{Pre-Standard}$ = Unit energy consumption of motors in each horsepower bin before the standard took effect

$UEC_{Post-Standard}$ = Unit energy consumption of motors in each horsepower bin after the standard took effect

$N_{Motors\ HP}$ = Projection of the number of electric motors sales in each horsepower bin in APS territory in 2015

$\%\ MShare_{HP}$ = Market share of each horsepower bin as a percentage of national unit sales

$Factors_{sector}$ = Technical factors including the line loss factor, coincidence factor (demand), and capacity reserve margin (demand)

Applying the above formula across horsepower categories yields the potential energy savings shown in Table 28. Each element of the calculation is explained in further detail below.

Table 28. 2015 APS Territory Potential Energy Savings from Electric Motors by Horsepower Category

Horsepower Bin	APS Territory Total Potential Savings (kWh)
1 through 5 hp	1,392,205
Greater than 5 through 20 hp	2,870,891
Greater than 20 through 50 hp	1,693,020
Greater than 50 through 100 hp	408,721
Greater than 100 through 200 hp	145,455
Greater than 200 through 500 hp	589,419
Total	7,099,711

Source: Navigant analysis

4.2.1 Unit Sales

4.2.1.1 National Unit Sales

Using national sales data from DOE[41], Navigant calculated the number of electric motors sold in 2015 (Table 29). Navigant also used these data to determine the relative weights of each horsepower category.

[41] U.S. Department of Energy. 2014 Electric Motors Final Rule. Available at http://www.regulations.gov/#!docketDetail;D=EERE-2010-BT-STD-0027.

Table 29. 2015 U.S. Electric Motor Sales

Horsepower (HP)	U.S. Motor Sales	Percentage by HP
1-5	3,665,391	64%
6-20	1,478,749	26%
21-50	373,338	7%
51-100	123,144	2%
101-200	40,449	0.7%
201-500	21,146	0.4%

Source: DOE

DOE provides motor sales by horsepower by sector[42] (Table 30). Using this data, Navigant calculated a breakdown of motor sales by sector—72 percent commercial and 28 percent industrial.

Table 30. DOE Electric Motors Sales by Horsepower and Sector

HP	Motor Sales by Sector		
	Industry	Agriculture	Commercial
1-5	26.11%	0.11%	73.78%
6-20	26.11%	0.11%	73.78%
21-50	26.11%	0.11%	73.78%
51-100	63.27%	6.98%	29.75%
101-200	76.03%	3.35%	20.62%
201-500	69.09%	3.03%	27.88%

Source: DOE

4.2.1.2 APS Unit Sales

Navigant applied adjustment factors to U.S. motors sales data to allocate national market data to APS territory-specific savings values. Navigant developed scaling factors for each relevant end-use sector (Table 31) using national, state, and APS 2015 electricity sales data from the Energy Information Administration[43]. Navigant applied these factors to the U.S. national sales data to estimate the share of electric motors distributed to customers in APS service territory (Table 32).

[42] U.S. Department of Energy. 2014 Electric Motors Final Rule. Technical Support Document, Table 7.2.6. http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0027-0108

[43] U.S. Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. http://www.eia.gov/electricity/data/eia826/

Table 31. APS Motors Scaling Factors based on Electricity Sales by Sector

Scaling Factor	Residential	Commercial	Industrial
NEMA Shipments by Sector	0%	72%	28%
Scalar – U.S. to AZ[44]	2%	2%	2%
Scalar - AZ to APS[45]	40%	43%	16%

Source: Navigant analysis

Table 32. 2015 Estimated Quantity of Motors Sales by Region

Region	Motors Sales
National	5,702,218
Arizona	70,787
APS	20,103

Source: Navigant analysis

4.2.2 Unit Energy Consumption

Using energy consumption data from DOE, Navigant calculated the unit energy consumption before and after standards (Table 33). The UEC for each horsepower bin represents the average UEC including both efficient and inefficient motors. The base case represents the average efficiency that would have occurred if the 2010 standards had not been enacted. The standards case includes the increased efficiencies that occurred as a result of the 2010 standards.

Table 33. 2015 Motor Unit Energy Consumption

HP	UEC (Base Case) *kWh*	UEC (Standards Case) *kWh*
1-5	2,822	2,724
6-20	18,396	17,892
21-50	56,989	55,810
51-100	154,389	152,400
101-200	310,401	307,446
201-500	888,047	870,361

Source: Navigant analysis

4.2.3 Program Influence Adjustment

Navigant did not apply a program influence adjustment to the motors analysis because the incentive program baseline changed from EPACT-complaint motors to EISA-compliant motors in 2012.

[44] Based on Arizona's share of total U.S. electricity sales in each sector
[45] Based on APS's share of total Arizona electricity sales in each sector

4.2.4 Technical Factors

Energy savings calculations included the line loss factor listed in Table 34. Demand savings calculations included the line loss factors, coincidence factor, and capacity reserve margin listed in Table 34.

Table 34. Technical Factor Adjustments for the Motors Analysis

Factor	Residential
Line Loss Factor (Energy)	7.0%
Line Loss Factor (Demand)	11.7%
Coincidence Factor	0.95
Capacity Reserve Margin	15%

Source: Navigant analysis

4.3 Gross Energy Savings

This section discusses the gross energy savings for motors. Gross energy savings are the potential energy savings adjusted for compliance rates.

Navigant's calculation of the gross energy savings accounts for the fact that not all motors covered under the standard will be sold at compliant levels of efficiency in 2015. Gross energy savings were calculated using the same formula as potential energy savings, with an added compliance percentage.

After investigating compliance rates with similar standards nationwide, and consulting industry experts, Navigant determined that 95 percent compliance is a reasonable rate for 2015.

4.4 Net Energy Savings

This section discusses the net energy savings for motors. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances.

The UEC values account for a mix of efficient and inefficient motors. Thus, NOMAD is accounted for in the potential energy savings calculation. Therefore, Navigant did not apply an additional adjustment for NOMAD of energy efficient motors. Consequently, net energy savings is equal to gross energy savings in this analysis.

4.5 Net C&S Program Savings

This section discusses the net C&S program savings for motors. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the effective useful lifetime for the technology. Navigant applied an EUL of 15 years,

consistent with its characterization for energy efficient motors rebated through the APS Solutions for Business program, and sourced from DEER 2008[46].

Navigant calculated net annual and lifetime energy and demand savings, savings and net C&S program savings shown in Table 35 using the values and adjustments noted above in conjunction with the equations listed in this section. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 2,248 MWh of annual energy savings, 33,724 of lifetime energy savings and 0.78 MW of demand savings from the federal EISA motors standard.

Table 35. APS Net Energy and Demand Savings at Generator from the EISA Motors Standard

Energy	kWh	MWh
Total Net Energy Savings	6,744,726	6,745
Net C&S Program Annual Energy Savings	**2,248,242**	**2,248**
Net C&S Program Lifetime Energy Savings	**33,723,628**	**33,724**
Demand	**kW**	**MW**
Total Net Demand Savings	2,335	2.34
Net C&S Program Demand Savings	**778**	**0.78**

Source: Navigant analysis

[46] http://www.deeresources.com/

5. RESIDENTIAL NEW CONSTRUCTION

This section describes the revised code and methodology for calculating savings for residential new construction. Table 36 summarizes the savings claimable by APS for residential new construction.

Table 36. 2015 APS Net Energy and Demand Savings at Generator from the Residential New Construction Code

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	6,848
Net C&S Program Lifetime Energy Savings	136,958
Net C&S Program Demand Savings	3.48

Source: Navigant analysis

5.1 Description of the Code

This section describes the relevant code for residential new construction.

Throughout the United States, residential building code pertaining to energy efficiency is defined by the International Energy Conservation Code (IECC). The IECC is updated at three-year intervals with a new vintage to keep current with the advancing standards of energy efficient design. As a home rule state, each jurisdiction (i.e., county or city) in Arizona is free to adopt any IECC vintage for its local building code. Consequently, in APS territory, there is a mixture of IECC code vintages from 2003 to 2012. Navigant's energy savings analysis is based on a combination of proposed code changes within APS service territory and energy simulation modeling.

5.2 Potential Energy Savings

This section discusses the potential energy savings for residential new construction code. Potential energy savings are the total energy savings from the standard change in APS territory, derived from market data and assuming 100 percent compliance.

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which a new building code in a particular jurisdiction is 100 percent effective on the day the code is implemented (full compliance). Navigant calculated potential energy savings using Equation 6:

Equation 6. APS-Territory-Wide Potential Energy Savings from Residential Building Codes (kWh)

$$\sum_{Jur}\sum_{Btype} Meters_{Btype} \times \left(\frac{kWh}{year}_{Btype,oldcode} - \frac{kWh}{year}_{Btype,newcode}\right) \times Factors$$

Where:

$Meters_{Btype}$ = New residential meter sets by building type (single-family or multifamily) installed within APS's service territory in 2015.

$\frac{kWh}{year}_{Btype,oldcode}$ = Baseline unit energy consumption (kWh/building-year), defined as the annual energy consumption of homes in compliance with the IECC vintage adopted by local building codes in 2012.

$\frac{kWh}{year}_{Btype,newcode}$ = Unit energy consumption (kWh/building-year) of homes compliant with the locally adopted IECC vintage in 2015.

$Factors$ = Technical factors such as the line loss factor (energy 7 percent; demand 11.7 percent), coincident demand ratio (3.71; for demand calculations only), and capacity reserve adjustment (0.15)

Equation 6 sums the potential energy savings, across every jurisdiction in APS's service territory, resulting from updates in residential building codes with more stringent IECC vintages. The baseline energy consumption, $kWh/year_{Btype,oldcode}$ represents the annual energy consumption of a new home if it were built to meet building code standards three years prior to the year being evaluated. For 2015, this means the code in place for a particular jurisdiction in 2012. Navigant's model applies this baseline assumption to mirror the three-year process of updating the IECC code. The three-year process represents the Naturally Occurring Rate of Standard Adoption (NOSAD). Therefore, the model defines "old code" as the code in each jurisdiction from three years ago, and savings claims from code adoption do not persist beyond three years after adoption of a new code.

5.2.1 Quantity of New Homes

Navigant used data on new residential meter sets as a proxy for new buildings in 2015. Table 37**Error! Reference source not found.** summarizes the distribution of all 13,203 meters across different climate zones in APS's service territory.

Table 37. 2015 APS New Residential Meter Installations by Climate Zone

Climate Zone	2015 New Single-Family Meters	2015 New Multifamily Meters	Total New Meters	New Meters as a Percent of Total
2B	7,250	4,066	11,316	86%
3B	124	0	124	1%
4B	1,065	7	1,072	8%
5B	570	121	691	5%
Total	**9,009**	**4,194**	**13,203**	**100%**

Source: Navigant analysis

5.2.2 Unit Energy Consumption

Navigant assigned unit energy consumption values according to building type (residential or multi-family), climate zone and IECC vintage using a suite of EnergyPlus[47] models calibrated to monthly APS billing data. Simulated consumption of code-compliant homes in Phoenix (climate zone 2B) is summarized in Table 38. Navigant investigated the code adoption schedules of the 104 jurisdictions in which APS installed new meters in 2015. Navigant modeled the energy consumption of new residential buildings in 2015 according to the latest IECC vintage adopted in each jurisdiction before July 1. Navigant's methodology requires unit consumption estimates for every vintage to establish baseline consumption. For instance, the Carefree building code adopted 2012 IECC standards in 2013, replacing 2003 IECC, so in this case Navigant developed unit energy consumption estimates for both 2003 and 2012 IECC vintages. The three-year baseline for 2015 savings is therefore the energy consumption levels modeled for 2003 IECC, while the efficient case is energy consumption levels modeled for 2012 IECC.

Table 38. Modeled Annual Residential Electricity Consumption by Code Vintage

Code Version	Modeled Single-Family Annual Consumption for Phoenix (kWh)	Modeled Multifamily Annual Consumption for Phoenix (kWh)
2003 IECC	16,317	7,506
2006 IECC	14,164	6,516
2009 IECC	12,794	5,886
2012 IECC	11,987	5,514

Source: Navigant analysis

5.2.3 Technical Factors

Energy savings calculations included the line loss factor listed in Table 39. Demand savings calculations included the line loss factors, coincidence factor, and capacity reserve margin listed in Table 39.

Table 39. Technical Factor Adjustments for the Residential New Construction Analysis

Factor	Residential
Line Loss Factor (Energy)	7.0%
Line Loss Factor (Demand)	11.7%
Capacity Reserve Margin	15%

Source: Navigant analysis

To calculate demand savings, Navigant applied a coincident demand ratio derived from the Energy Star Legacy Database according to Equation 7.

[47] Navigant created the models to support this effort as well as measurement and evaluation of APS's ENERGY STAR Homes Program. EnergyPlus is a whole building energy simulation program that engineers, architects, and researchers use to model both energy consumption—for heating, cooling, ventilation, lighting, and plug and process loads—and water use in buildings. http://apps1.eere.energy.gov/buildings/energyplus/

Equation 7. Calculating Annual Demand Savings from the Residential Building Codes

$$\left(\frac{kWh\ savings}{8760}\right) * (1 + LLF) * CDR * (1 + CRM) = kWsavings$$

Where:

$\frac{kWh\ savings}{8760}$	= Total energy savings (kWh) divided by the number of hours in a year
$1 + LLF$	= accounting for the demand line loss factor (11.7 percent)
CDR	= accounting for the coincident demand ratio (3.71)
$1 + CRM$	= accounting for the capacity reserve margin (15 percent)

Navigant calculated potential energy savings from residential building codes as approximately 29 million kWh in 2015, as shown in Table 40.

Table 40. 2015 APS Territory Potential Energy Savings by Housing Category

Housing Category	APS Territory Potential Savings (kWh)
Single-Family	20,522,047
Multifamily	8,734,176
Total Potential Savings	29,256,224

Source: Navigant analysis

5.3 Gross Energy Savings

Following discussions with APS staff familiar with building practices in Arizona and a survey of code compliance studies conducted throughout the United States, Navigant developed a compliance schedule to account for the fact that construction practices adapt to new building codes over several years.

Table 41 summarizes compliance adjusted unit consumption for the six permutations of code updates. The Year 1 values reflect a 65% first year compliance rate as the average unit energy consumption in a jurisdiction where 65% of new buildings are compliant with the newly adopted IECC code and 35% only meet the preexisting code. Similarly, columns two and three (Year 2 and Year 3) reflect 75% and 90% compliance. The fourth column (Year 4) is the unit energy consumption of buildings compliant with the newly adopted code (100% compliance). Navigant calculated the values in Table 41 according to Equation 8.

Table 41. Modeled Code Consumption Adjusted for Compliance Rates

Old Code and New Code	Compliance Adjusted Consumption (kWh)			
	Year 1	Year 2	Year 3	Year 4
2003 to 2006	14,918	14,702	14,379	14,164
2003 to 2009	14,027	13,675	13,146	12,794
2003 to 2012	13,503	13,070	12,420	11,987
2006 to 2009	13,274	13,137	12,931	12,794
2006 to 2012	12,749	12,531	12,205	11,987
2009 to 2012	12,269	12,189	12,068	11,987
Compliance Rates	66%	75%	90%	100%

Source: Navigant analysis

Equation 8. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Homes

$$Compliance\ Rate \times \frac{kWh}{year}_{newcode} + (1 - Compliance\ Rate) \times \frac{kWh}{year}_{oldcode}$$

Where:

$\frac{kWh}{year}_{oldcode}$ = Modeled consumption (kWh/year) of a building compliant with the preexisting IECC vintage following the update.

$\frac{kWh}{year}_{newcode}$ = Modeled consumption (kWh/year) of a home built to compliance with the newly adopted vintage. In this context, a code is newly adopted until the fourth year of implementation, when 100% compliance is assumed.

$Compliance\ Rate$ = Fraction of newly constructed buildings compliant with the newly adopted vintage, according to the number of years passed since adoption.

Gross energy savings are calculated by replacing the unit energy consumption in Equation 6 with the compliance adjusted values summarized in Table 41. The results for 2015, summed across all jurisdictions in APS's service territory, are summarized in Table 42.

Table 42. 2015 APS Territory Gross Energy Savings by Housing Category

Housing Category	APS Territory Gross Savings (kWh)
Single-Family	14,629,707
Multifamily	5,914,065
Total Gross Savings	20,543,773

Source: Navigant analysis

5.4 Net Energy Savings

This section discusses the net energy savings for residential new construction code. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient building practices.

Navigant did not apply further adjustments to the gross energy savings values presented in Table 42. However, the three-year baseline consumption levels developed in Section 5.2 were chosen to reflect NOMAD of efficient building practices under the assumption that the market progresses at the same rate as adoption of new building codes. Therefore, in this analysis, net savings are the same as gross savings.

5.5 Net C&S Program Savings

This section discusses the net C&S program savings for residential new construction code. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the effective useful lifetime for the technology. Navigant applied an EUL of 20 years, consistent with characterization of residential new construction projects rebated through the APS Residential New Construction program.

Navigant calculated net annual and lifetime energy and demand savings shown in Table 43 using the values and adjustments noted above in conjunction with the equations listed in this section. The net energy savings equal the gross energy savings from Table 42 above, because no further compliance or NOMAD adjustments were applied to potential savings. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 6,848 MWh of annual energy savings, 136,958 MWh of lifetime energy savings, and 3.48 MW of demand savings from the jurisdictional IECC residential building codes.

Table 43. 2015 APS Net Energy and Demand Savings at Generator from Residential Building Codes

	kWh	MWh
Net Energy Savings – Single-Family	14,629,708	14,630
Net Energy Savings – Multifamily	5,914,065	5,914
Total Net Energy Savings	20,543,773	20,544
Net C&S Program Energy Savings	**6,847,924**	**6,848**
Net C&S Program Lifetime Energy Savings	**136,958,487**	**136,958**
	kW	**MW**
Net Demand Savings – Single-Family	7,428	7.43
Net Demand Savings – Multifamily	3,003	3.00
Total Net Demand Savings	**10,431**	**10.43**
Net C&S Program Demand Savings	**3,477**	**3.48**

Source: Navigant analysis

6. COMMERCIAL NEW CONSTRUCTION

This section describes the revised code and methodology for calculating savings for commercial new construction. Table 44 summarizes the savings claimable by APS for commercial new construction.

Table 44. 2015 APS Net Energy and Demand Savings at Generator from the Commercial New Construction Code

Savings Type	Savings (MWh)
Net C&S Program Energy Savings	4,546
Net C&S Program Lifetime Energy Savings	90,922
Net C&S Program Demand Savings	1.05

Source: Navigant analysis

6.1 Description of the Code

This section describes the relevant code for commercial new construction.

Just as the energy efficiency standards in residential building codes in the United States are defined by the IECC, the efficiency standards in commercial building codes are defined by ASHRAE 90.1. Each jurisdiction is similarly free to choose among the various ASHRAE 90.1 vintages, but the choice is not generally independent of the IECC vintage applied to residential building codes: the 2004, 2007, and 2010 vintages of ASHRAE 90.1 correspond to the 2006, 2009, and 2012 vintages, respectively, of IECC[48]. Therefore, as in the residential sector, the efficiency standards for new commercial buildings are not uniform across APS territory.

6.2 Potential Energy Savings

This section discusses the potential energy savings from commercial new construction codes. Potential energy savings are the total energy savings from the code change in APS territory, derived from market data and assuming 100 percent compliance.

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which a new building code in a particular jurisdiction is 100 percent effective on the day the code is implemented (full compliance). Navigant calculated potential energy savings using Equation 9:

Equation 9. APS-Territory-Wide Potential Energy Savings from Commercial Building Code (kWh/year)

$$\sum_{Jur}\sum_{Btype}\left(\frac{kWh}{year\cdot sqft}_{oldcode,Btype}-\frac{kWh}{year\cdot sqft}_{newcode,Btype}\right)\times Sqft_{Btype}\times Factors_{Btype}$$

[48] For a detailed discussion of the parallels between IECC and ASHRAE90.1, see:
U.S. Department of Energy. "Building Energy Codes 101: An Introduction." February 2010. PNNL-SA-70586.

Where:

$\frac{kWh}{year \cdot sqft_{oldcode,Btype}}$ = Baseline energy usage intensity (EUI) (kWh/yr-ft^2) by building type, defined as the annual energy consumption of buildings in compliance with the ASHRAE 90.1 vintage adopted by local building codes in 2012.

$\frac{kWh}{year \cdot sqft_{newcode,Btype}}$ = Efficient EUI (kWh/yr-ft^2) by building type of buildings compliant with locally adopted ASHRAE 90.1 vintages in 2015.

$Sqft_{Btype}$ = Total floor space (ft^2) by building type across all commercial buildings within each jurisdiction built in 2015.

$Factors_{Btype}$ = Technical factors such as the line loss factor (energy 7 percent; demand 11.7 percent), coincidence factors (by building type), and capacity reserve adjustment (15 percent)

Equation 9 sums the potential energy savings, across every jurisdiction in APS service territory, resulting from updates in commercial building codes applied to 23 building types. The baseline energy consumption, *kWh/yr-sqft$_{oldcode,Btype}$*, represents the annual energy consumption of a new building if it were built to meet building code standards three -years prior to the year being evaluated. For 2015, this means the code in place for a particular jurisdiction in 2012. Navigant's model applies this baseline assumption to mirror the three-year process of ASHRAE 90.1 code updates. The three-year process represents the Naturally Occurring Rate of Standard Adoption (NOSAD). Therefore, the model defines "old code" as the code in each jurisdiction from three years ago, and savings claims from code adoption do not persist beyond three years after adoption of a new code. Navigant calculated potential energy savings from commercial building codes as 29,396 MWh in 2015.

6.2.1 Commercial Floor-space Constructed

APS provided Navigant with a list of new meters installed in commercial facilities in 2015. This list included a building type designation determined by APS. By examining the APS definition and DOE definition of each building type, Navigant assigned corresponding DOE building types to each APS designation as shown in Table 46.

Similarly, the DOE prototype models are built to national average sizes by each building type. In order to obtain region-specific size data for each building type, Navigant used a combination of data from third-party databases maintained by Dodge Construction and CoStar. When lacking sufficient building size data, Navigant used the DOE prototype sizes, as shown in Table 46.

6.2.2 Unit Energy Consumption

To determine unit energy savings per square foot of new commercial floor space by building type, climate zone, and code vintage; Navigant used a suite of commercial prototype building energy models with code-compliant inputs provided by DOE[49]. The simulated consumption of each code-compliant building by type and climate zone is shown in Table 45.

[49] Department of Energy. Building Energy Codes Program. https://www.energycodes.gov/commercial-prototype-building-models

Navigant investigated the code adoption schedules of 75 jurisdictions in which APS installed new meters in 2015. Navigant considered a code effective in 2015 if the jurisdiction adopted the code before July 1. If the code was adopted after July 1, Navigant considered the code effective in 2016 and beyond.

In each jurisdiction, the new meters were further disaggregated by building type, and the appropriate EUIs were applied according to climate zone, building type, and code vintage.

Table 45. Energy Use Intensity by Building Type, Code Vintage, and Climate Zone

DOE Prototype Model	DOE Building Area	Electricity Use (kWh/sq ft)											
		ASHRAE 90.1 2004				ASHRAE 90.1 2007				ASHRAE 90.1 2010			
		CZ 2B	CZ 3B	CZ 4B	CZ 5B	CZ 2B	CZ 3B	CZ 4B	CZ 5B	CZ 2B	CZ 3B	CZ 4B	CZ 5B
Secondary School	210,886	17.2	14.3	13.1	12.4	16.0	13.3	12.3	11.7	12.8	10.8	10.0	9.4
Strip Mall	22,500	20.3	17.4	16.1	15.4	19.1	15.7	14.8	14.1	15.0	12.6	12.0	11.5
Primary School	73,959	18.1	15.6	14.5	13.5	17.0	14.7	13.7	13.0	13.9	11.9	11.2	10.7
Stand-alone Retail	24,692	20.0	16.7	15.7	15.4	17.5	15.7	14.9	14.2	13.8	12.5	12.0	11.5
Medium Office	53,628	14.1	12.2	12.1	12.2	13.6	11.8	11.5	11.6	10.4	8.8	8.5	8.4
Large Hotel	122,120	24.6	19.3	17.1	16.0	22.6	18.8	16.9	15.9	20.1	17.1	15.7	14.7
Full Service Restaurant	5,502	67.9	60.5	56.5	54.1	65.4	58.5	54.5	51.9	49.3	44.0	38.8	37.4
Hospital	241,501	30.7	27.8	27.2	25.9	30.5	27.7	27.1	26.0	24.9	23.1	22.8	21.8
Quick Service Restaurant	2,501	76.5	66.9	62.4	60.0	77.5	68.0	62.7	59.5	68.2	59.6	53.7	51.9
Small Hotel	40,096	16.0	14.8	14.1	13.7	15.3	14.2	13.7	13.4	13.6	12.7	12.3	12.0
Outpatient Healthcare	40,946	38.7	37.0	36.8	35.3	36.8	35.1	34.5	33.4	30.2	28.4	27.6	26.0
Warehouse	52,045	5.9	4.6	4.3	4.3	5.8	4.6	4.3	4.3	4.6	3.4	3.1	3.2

Source: Navigant analysis

Table 46. Summary of APS and DOE Building Types and Sizes

APS Designation	DOE Prototype Model	DOE Building Area (sq ft)	AZ Building Area (sq ft)
College/University	Secondary School	210,886	153,985
Department Store	Strip Mall	22,500	18,225
Elementary School	Primary School	73,959	114,960
Grocery/Convenience Store	Stand-alone Retail	24,692	18,225
Halls	Medium Office	53,628	28,190
High School	Secondary School	210,886	114,960
Hotel	Large Hotel	122,120	73,712
Indust/Mfg/Process	Full Service Restaurant	5,502	4,668
Inpatient Facility	Hospital	241,501	126,965
Jr High/Middle School	Secondary School	210,886	114,960
Laundry/Cleaning Service	Quick Service Restaurant	2,501	2,501
Motel	Small Hotel	40,096	73,712
Office	Medium Office	53,628	28,190
Outpatient Facility	Outpatient Healthcare	40,946	40,946
Resort	Large Hotel	122,120	73,712
Restaurant or Bar	Full Service Restaurant	5,502	5,407
Retail – Exterior Entry	Stand-alone Retail	24,692	15,002
Retail – Int/Ext Entry	Stand-alone Retail	24,692	15,002
Retail – Interior Entry	Strip Mall	22,500	15,002
Spa/Gymnasium	Small Hotel	40,096	73,712
Take-Out Food	Quick Service Restaurant	2,501	2,501
Warehouse	Warehouse	52,045	55,704
Wholesale-Type Store	Warehouse	52,045	55,704

Source: Navigant analysis

6.2.3 Technical Factors

Energy and demand savings calculations included line loss factors (7 percent energy and 11.7 percent demand), coincidence factors (by building type), and capacity reserve margins (15 percent, demand only). Navigant derived coincidence factors from the hourly output of the DOE prototype energy models using APS peak hours of non-holiday weekdays between 4pm and 6pm from June to August. Navigant determined a coincidence factor by building type (Table 47) and multiplied energy savings by the coincidence factor to calculate demand savings.

Table 47. Coincidence Factors by Building Type

DOE Prototype Model	Coincidence Factor
Secondary School	0.00020
Strip Mall	0.00024
Primary School	0.00015
Stand-alone Retail	0.00026
Medium Office	0.00017
Large Hotel	0.00015
Full Service Restaurant	0.00020
Hospital	0.00011
Quick Service Restaurant	0.00018
Small Hotel	0.00018
Outpatient Healthcare	0.00015
Warehouse	0.00012

Source: Navigant analysis

Further, Navigant applied a data integrity adjustment as a result of evaluation research activities conducted in 2014. Navigant sampled a statistically valid number of buildings (n=438) within each building type from new meter installation data between 2009 and 2013. Using county assessors data, commercial real estate data, and satellite photos[50], Navigant confirmed the vintage, actual building type, and size of each building. Navigant concluded that 68 percent of APS meters labeled as "new" are installed in applications other than new construction or major renovations, and therefore cannot be included in the derivation of code savings. Therefore, for 2015 savings verification, Navigant applied a 32 percent adjustment factor to the number of buildings identified in the new meter set data, across all building types.

6.3 Gross Energy Savings

This section discusses the gross energy savings for commercial new construction code. Gross energy savings are the potential energy savings adjusted for compliance rates.

After informal interviews with APS staff familiar with building practices in Arizona, and a survey of code compliance studies conducted throughout the United States, Navigant developed a compliance rate to account for the fact that building practices can take significant time to adapt to a code change. As shown in Table 48, the analysis assumes 65 percent compliance in the first year of adoption, with full compliance achieved by the fourth year after adoption. Annual EUI adjustments are based on the increasing compliance rates, as calculated in Equation 10.

[50] The research relied on a combination of the most up to date sources using satellite photos from Google Earth ( ) and Google Maps ( ); as well as publically available county assessors data aggregated by Loopnet ( ) and Trulia ( ).

Table 48. Compliance Rate Assumptions for Commercial New Construction Codes

	Year 1	Year 2	Year 3	Year 4
Compliance Rates	65%	75%	90%	100%

Source: Navigant analysis

Equation 10. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Buildings

$$Compliance \times \frac{kWh}{year \cdot sqft_{oldcode,Btype}} + (1 - Compliance) \times \frac{kWh}{year \cdot sqft_{newcode,Btype}}$$

Where:

$\frac{kWh}{year \cdot sqft_{oldcode,Btype}}$ = Modeled consumption (kWh) of a building compliant with the preexisting AHRAE 90.1 vintage following the update.

$\frac{kWh}{year \cdot sqft_{newcode,Btype}}$ = Modeled consumption (kWh) of a home built to compliance with the newly adopted vintage. In this context, a code is newly adopted until the fourth year of implementation, when 100% compliance is assumed.

$Compliance$ = Fraction of newly constructed buildings compliant with the newly adopted vintage, according to the number of years passed since adoption.

6.4 Net Energy Savings

This section discusses the net energy savings for commercial new construction code. Net energy savings are the gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient building practices.

Navigant did not apply further adjustments to the gross energy savings values. However, the three-year baseline consumption levels were chosen to reflect NOMAD of efficient building practices under the assumption that the market progresses at the same rate as adoption of new building codes. Therefore, in this analysis, net savings are the same as gross savings.

6.5 Net C&S Program Savings

This section discusses the net C&S program savings for commercial new construction code. Net C&S program savings are the net energy savings from APS's C&S program, adjusted for the ACC prescribed one-third allowance.

Navigant calculated net C&S program savings for all codes and standards under consideration in 2015 as one-third of net energy, which is permitted under ACC R-14-2.

Navigant calculated lifetime net C&S program energy savings by multiplying annual net C&S program energy savings by the EUL for the technology. Navigant applied an EUL of 20 years, consistent with its characterization for commercial new construction projects rebated through the APS Solutions for Business program.

Navigant calculated net annual and lifetime energy and demand savings, and net C&S program savings shown in Table 49 using the methodology and factors discussed above. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 4,546 MWh of annual energy savings, 90,922 MWh of lifetime energy savings, and 1,047 kW of demand savings from the jurisdictional ASHRAE 90.1 commercial building codes.

Table 49. 2015 APS Net Energy and Demand Savings at Generator from Commercial Building Codes

	kWh	MWh
Total Net Energy Savings	13,638,285	13,638
Net C&S Program Annual Energy Savings	**4,546,095**	**4,546**
Net C&S Program Lifetime Energy Savings	**90,921,904**	**90,922**
	kW	**MW**
Total Net Demand Savings	3,141	3.14
Net C&S Program Demand Savings	**1,047**	**1.05**

Source: Navigant analysis

APPENDIX A. CODES AND STANDARDS MEASUREMENT AND EVALUATION PLAN

A.1 Introduction

As stated in section R14-2-2404 part E of the Electric Energy Efficiency Standards[51],

> *"An affected utility may count toward meeting the standard up to one third of the energy savings, resulting from energy efficiency building codes, that are quantified and reported through a measurement and evaluation study undertaken by the affected utility."*

Furthermore, the ACC allows APS to include savings "resulting from improved energy efficiency appliance standards."[52] The following memo presents Navigant's proposed methodology to evaluate APS's savings claims from recent changes to building codes and appliance standards.

A.2 Determining Relevant Codes and Standards Updates

A review of federal, state, and jurisdictional code changes in 2015 revealed the following code updates of interest to APS:

[51] Docket No. RE-00000C-09-0427 (Electric Energy Efficiency Rules) Title 14, Chapter 2, Article 24, section R14-2-2404.

[52] Docket No. E-01345A-11-0232; Decision No. 73089 pg. 56 Line 11

Table 50. Relevant Code Updates in APS Territory

Measure	Old Code	New Code	Authority	Effective Year
General Service Lamps	None	EISA[53]	Federal	2012, 2013, 2014
Linear Fluorescents	EPACT 1992	DOE Federal Rulemaking[54]	Federal	2012
Residential Air Conditioners and Heat Pumps	DOE Federal Rulemaking[55]	DOE Federal Rulemaking[56]	Federal	2015
Motors	EPACT 1992	EISA	Federal	2010
Residential New Construction	IECC 2003, 2006, 2009 (by jurisdiction)	IECC 2006, 2009, 2012 (by jurisdiction)	Jurisdictional	Various
Commercial New Construction	ASHRAE 90.1 2007, 2010	ASHRAE 90.1 2010, 2013	Jurisdictional	Various

Source: Navigant analysis

The first four rows in Table 50 are standards that apply to specific appliances across building types. The last two rows are energy codes that set minimum requirements for the energy systems of a particular building by building type. C&S are established at the federal, state, or jurisdictional level. Establishing C&S at the federal level is typically a complex, long term and nationwide effort. Statewide C&S efforts are more localized, and therefore responsive to influence from stakeholders and utilities within the state. At the jurisdictional level, city and county governments may look to the utilities that serve their territory for guidance and support in the C&S process. Evaluation of C&S programs should consider these differences when calculating the portion of savings that could be attributed to the utilities' efforts.

A.3 Developing an Approach for Evaluating Savings Estimates

Determining savings from C&S is a relatively new practice that is still under development throughout the United States. So far, only a few state utility commissions allow constituent utilities to claim savings from C&S upgrades, but support for fulfilling statewide efficiency goals through C&S programs is on the rise[57]. Navigant strives to estimate savings claims as accurately as possible given budget and data constraints. Inevitably, assumptions will arise, in which case Navigant will err on the conservative side, knowing that

[53] Energy Independence and Security Act of 2007. Public Law 110-140, 110th Congress. December 19, 2007. http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

[54] U.S. Department of Energy. "*Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.*" July 14, 2009. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf

[55] U.S. Department of Energy. "*Energy Conservation Program for Consumer Products: Central Air Conditioners and Heat Pumps Energy Conservation Standards; Final Rule; technical correction.*" http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0089-0398

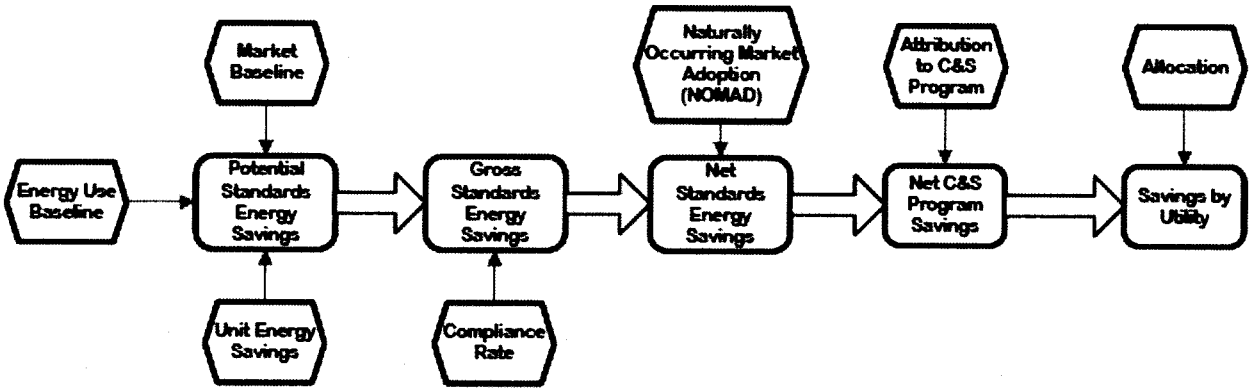
[56] U.S. Department of Energy. "*Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps; Direct Final Rule.*" http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0011-0001

[57] For a review of the latest developments in C&S programs by state see Misuriello, H. *Building Energy Code Advancement through Utility Support and Engagement.* ACEEE Report number A126, December 2012.

our approach in Arizona will be reviewed closely on a local and national level among the energy efficiency community. As C&S programs in Arizona and nationwide become more established, Navigant will continue to refine the C&S evaluation methodology based on best practices and available data.

Practitioners in California have developed an industry standard C&S program evaluation protocol, which Navigant proposes to use as a template for C&S program evaluations (see Figure 4). All of the following factors warrant consideration, but may not be assessed for each measure of interest based on availability of data, the specific characteristics of the measure, and the relative magnitude of the C&S savings for each measure. The remainder of this memo explains the process outlined in Figure 4.

Figure 4. C&S Advocacy Program Evaluation Protocol



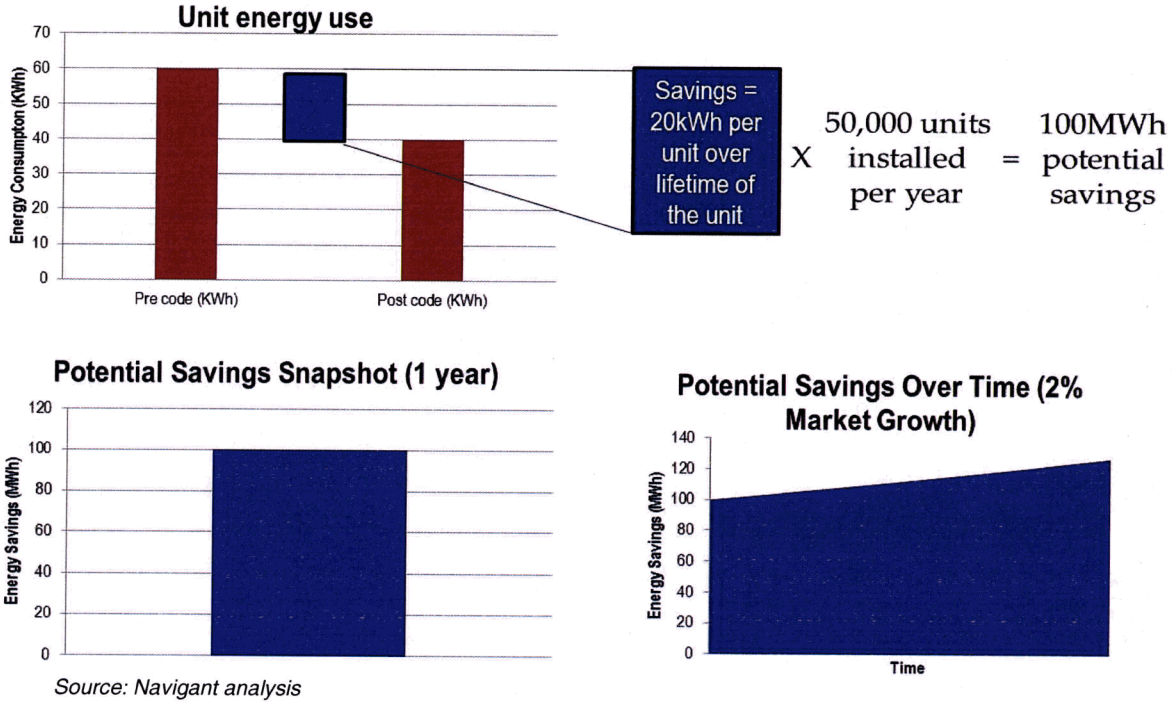
Source: 2008 ACEEE Summer Study on Energy Efficiency in Buildings[58]

1. Potential Energy Savings: the energy savings estimated if all buildings were in full compliance with the new code or standard. Figure 5 graphically represents the components of a potential energy savings calculation.[59]

[58] Lee, A. et al. *Utility Codes and Standards Programs: How Much Energy do they Save?* 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

[59] Figures 2-6 are for illustrative purposes only and do not reflect actual data from any measures.

Figure 5. Unit Energy Savings x Market Size = Potential Energy Savings



Source: Navigant analysis

a. Energy Use Baseline: Baseline energy use data related to the building or appliance of interest. This information is used to establish how many buildings or appliances in the underlying market were code compliant, not code compliant, or exceeded compliance prior to adoption of the new code.

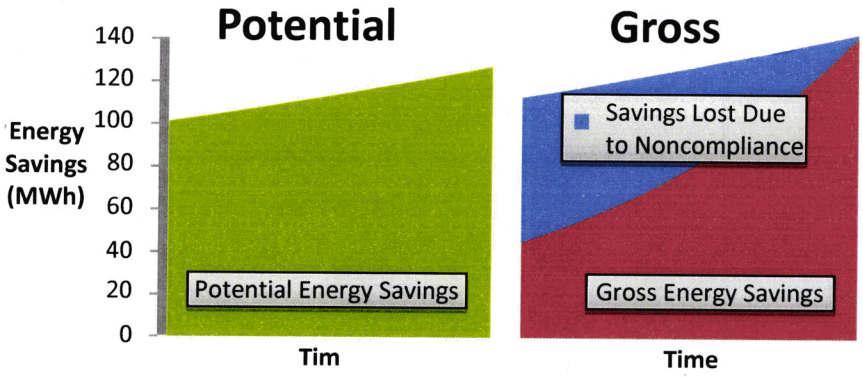
b. Market Baseline: the number of actual units built/sold in the year prior to the code implementation and the year after the code implementation. This information, along with the compliance rate, will be used to determine avoided sales (i.e., the number of pre-code appliances or buildings that were not purchased or built as a result of the code implementation). Navigant will consider the market baseline as part of the NOMAD (as depicted in Figure 4) analysis in step 3. Navigant will adjust the market baseline with program data provided by APS to avoid double-counting any units that were installed by program participants.

c. Unit Energy Savings: Consumption of code-compliant units vs. pre-code units.

2. Gross Energy Savings: Potential energy savings discounted by code compliance rates. In the year after code adoption, the compliance rate is likely to be significantly less than 100 percent as the market adapts to new regulations. A utility can achieve greater savings by supporting code compliance in its service territory. In Figure 6, the compliance rate begins at 40 percent and grows to full compliance over time, thereby reducing the savings lost due to noncompliance.

a. Compliance Rate: The degree to which the code update is realized within the actual market for new buildings or appliances. The compliance rate helps to determine a new "blended baseline" after code adoption. The blended baseline accounts for the mix of code-compliant units and non-code-compliant units in the market.

Figure 6. Potential Energy Savings and Gross Energy Savings

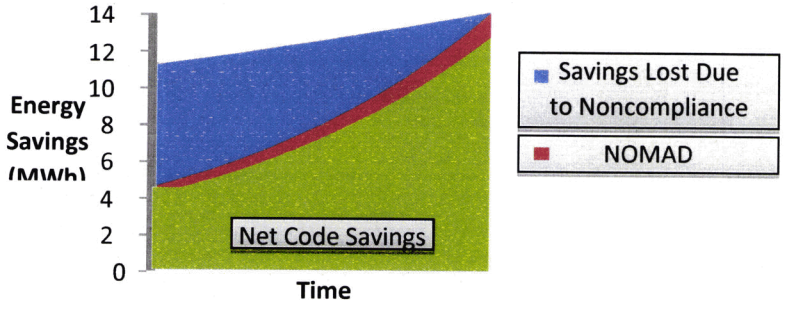


Source: Navigant analysis

3. Net Energy Savings: gross savings discounted by assumptions about natural rates of market and C&S adoptions, as well as C&S compliance rates.[60] Figure 7 illustrates this adjustment, starting with gross energy savings and removing a "slice" for NOMAD.

    a. Naturally Occurring Market Adoption: The rate of adoption of energy efficient measures that would have happened anyway, absent the C&S revision. NOMAD is depicted in the figures to illustrate the concept. However, to maintain consistency with the evaluation methodology of other APS programs, the net-to-gross ratio is assumed to be 1, meaning there are no market effects or naturally occurring rates of market adoption considered in our C&S analysis.

Figure 7. Adjustment for Natural Rates of Market Adoption



Source: Navigant analysis

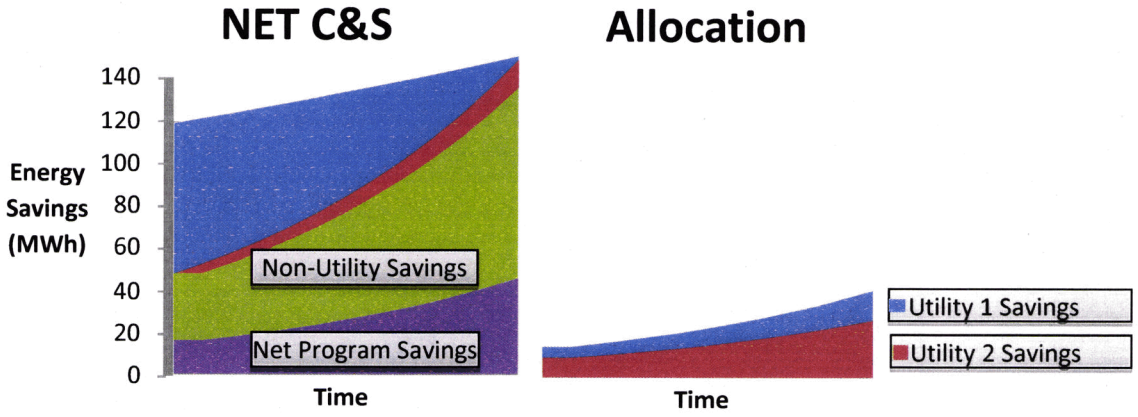
    b. Naturally Occurring Standards Adoption (NOSAD): Navigant has experience conducting expert interviews to determine the counterfactual case for standards adoption (*e.g.*, when

[60] Some versions of this analysis include an intermediate step. For instance, the first step is referred to as Potential Energy Savings, the second step is Gross Energy Savings which is adjusted by the code compliance rate only, and the third step is Net Energy Savings adjusted from Gross by NOMAD (see Misuriello, H. *Building Energy Code Advancement through Utility Support and Engagement.* ACEEE Report number A126, December 2012). This methodology isolates the market effects in a single distinct step, rather than including them with NOMAD and NOSAD as we have outlined in this memo. The end result is equivalent.

a code or standard would have been updated absent the effect of utility efforts). This information is used to determine the period over which savings from C&S can be claimed. NOSAD effects are illustrated in Figure 9.

4. Net Program Savings: a quantification of a utility's efforts to achieve energy savings through C&S updates. In Figure 8, the purple area is one-third of net code savings from Figure 7.
    a. Net C&S program savings: After net standard savings are determined, the savings resulting from utility's efforts must be determined. In Arizona, pursuant to the rule established by the ACC, a utility may count up to 1/3 of the energy savings resulting from C&S updates within its service territory as verified by measurement and evaluation. Navigant will apply the ACC prescribed rate of one-third until further direction on the appropriate level or method of attribution is provided.
5. Savings by Utility: In Figure 8, the net program savings are divided between utilities serving customers within the C&S authority that passes the new code or standard, if more than one utility is serving customers in the authority of interest.
    a. Allocation: Savings can only be claimed for effects that occur within APS service territory. Ideally, Navigant will obtain APS service territory-specific data on appliance and new construction markets (*i.e.*, for residential new construction, the number of residential new meters set by APS in a particular year). Often, the available data includes areas outside of APS service territory, in which case allocation must be determined. This allocation can be accomplished based on the number of customers each utility serves relative to the total market population or other proxies appropriate to the situation.

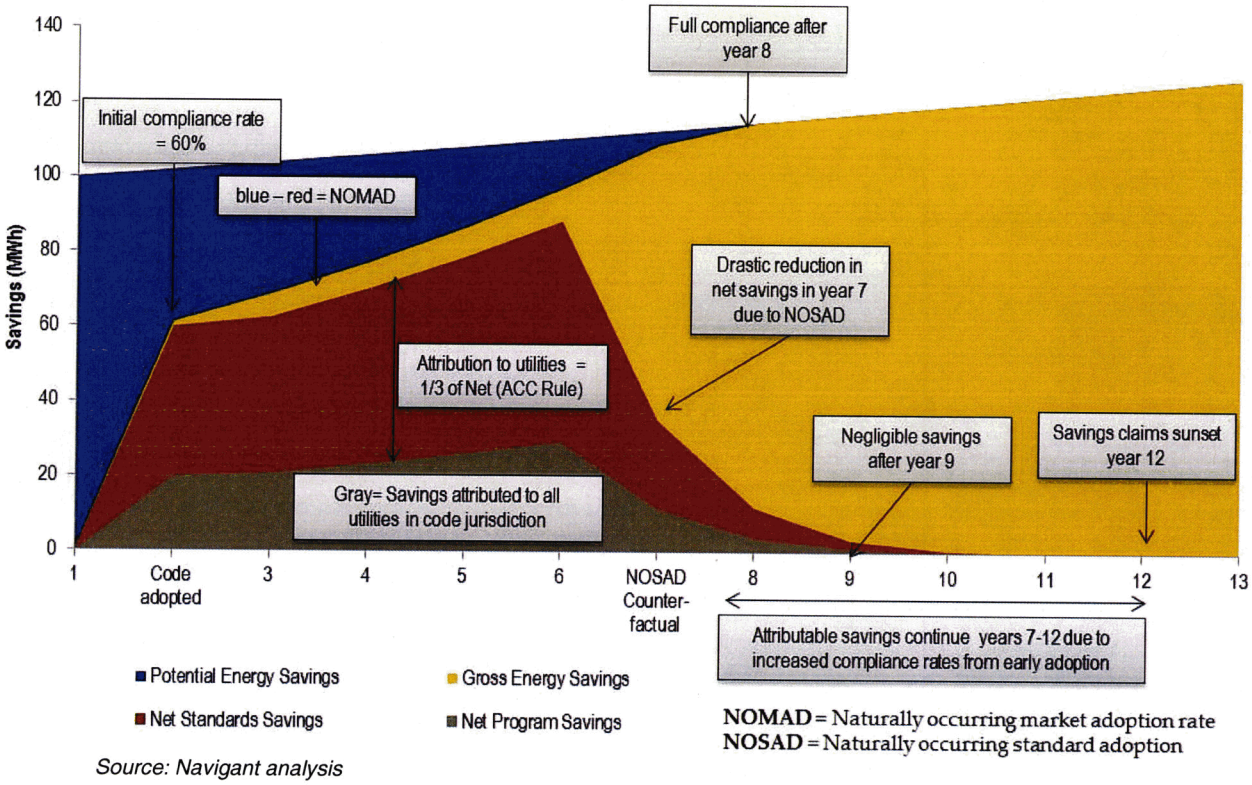
Figure 8. Adjustment for Net Program Savings, and Allocation by Utility



Source: Navigant analysis

Figure 9 is a longitudinal summary of all of the various steps in the C&S evaluation process, including consideration of the NOSAD rate.

Figure 9. The C&S Evaluation Process over Time



Source: Navigant analysis

This figure illustrates energy savings for a hypothetical "widget" code adopted in year 2 with an initial compliance rate of 60 percent. Potential energy savings increase every year as the market size of widgets grows at 2 percent per year. It takes seven years for the market of new widgets to comply completely with the adopted code (100 percent compliance), at which point gross savings equals potential savings. Discounting gross savings by NOMAD yields net savings. Net savings are determined by applying the ACC prescribed allowance of one-third, which yields net C&S program savings. These net program savings would then need to be allocated among the utilities that serve the area within the code authority (federal, state, or jurisdictional—allocation not shown).

Figure 9 also represents NOSAD—when the widget code would have been adopted absent the influence of the utilities. In this example, NOSAD occurs in year 7, five years after the code was actually adopted. However, C&S savings continue after NOSAD, due to the increased code compliance rates that were "banked" in years 2 to 6 as a result of the utilities' efforts to encourage code adoption earlier than it would have occurred otherwise. In other words, NOSAD does not immediately cancel all C&S savings, since it is assumed that the NOSAD would have begun with only a 60 percent compliance rate in the first year of C&S adoption.

APPENDIX B. LINEAR FLUORESCENT WATTAGES AND MARKET SHARE DATA

As discussed in section 2.2.2, using data provided by DOE[61], Navigant determined wattages of various lamp and ballast combinations. T12 and 700 series T8 lamps represent the baseline prior to the standard change (W_{T12} and $W_{T8\ 700\ series}$) and premium T8 lamps represent the baseline after the standard change ($W_{T8\ Premium}$). Navigant calculated a weighted average wattage for each lamp (Table 17) based on national market share estimates. The following tables show the data that Navigant used from DOE. Navigant determined that each lamp system contained three lamps for both T12 and T8 systems.

Table 51. Residential T12 Lamp System Characteristics

DOE Efficacy Level	System Wattage		Market Share	
	Initial Ballast	New Ballast	Initial Ballast	New Ballast
0	70	70	51%	25%
0	60	60	7%	4%
1	70	70	32%	16%
1	60	60	1%	1%
1	70	70	5%	3%
2	60	60	0%	0%
2	70	70	4%	2%
3	60	60	0%	0%
0	-	58	-	25%
0	-	60	-	3%
1	-	58	-	16%
1	-	60	-	1%
1	-	58	-	3%
2	-	60	-	0%
2	-	58	-	2%
3	-	60	-	0%

Source: DOE

[61] Department of Energy. "*Final Rule Technical Support Document: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps*". July 2009. http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0131-0147

Table 52. Commercial T12 Lamp System Characteristics

DOE Efficacy Level	System Wattage		Market Share	
	Initial Ballast	New Ballast	Initial Ballast	New Ballast
0	129	107.7	0%	0%
0	108	91.7	80%	80%
1	129	107.7	6%	6%
1	108	91.7	6%	6%
1	129	107.7	3%	3%
2	108	91.7	3%	3%
2	129	107.7	1%	1%
3	108	91.7	1%	1%

Source: DOE

Table 53. Residential T8 Lamp System Characteristics

DOE Efficacy Level	Ballast Factor	System Wattage	Market Share			
			Initial Ballast		New Ballast	
			Base Case	Standards Case	Base Case	Standards Case
2	0.88	58.6	49%	0%	10%	0%
3	0.88	58.6	25%	0%	5%	0%
4	0.88	58.6	6%	31%	6%	11%
4	0.88	54.6	1%	50%	1%	1%
4	0.88	45.4	2%	2%	2%	2%
5	0.88	58.6	4%	4%	0%	0%
5	0.88	51.2	3%	3%	3%	3%
2	0.78	51.6	0%	0%	10%	0%
3	0.78	51.6	2%	0%	9%	0%
4	0.78	51.6	2%	4%	2%	12%
4	0.78	48.9	0%	0%	0%	0%
4	0.78	40.5	1%	1%	1%	1%
5	0.78	51.6	0%	0%	2%	2%
5	0.78	45.6	0%	0%	0%	0%
2	0.71	46.8	0%	0%	29%	0%
3	0.71	46.8	2%	0%	15%	0%
4	0.71	46.8	2%	4%	2%	36%
4	0.71	44.9	0%	0%	0%	29%
4	0.71	37	1%	1%	1%	1%
5	0.71	46.8	0%	0%	2%	2%
5	0.71	41.7	0%	0%	0%	0%

Source: Navigant analysis

Table 54. Commercial T8 Lamp System Characteristics

DOE Efficacy Level	Ballast Factor	System Wattage	Market Share			
			Initial Ballast		New Ballast	
			Base Case	Standards Case	Base Case	Standards Case
2	0.88	86.8	49%	0%	49%	0%
3	0.88	86.8	25%	0%	25%	0%
4	0.88	86.8	6%	31%	6%	31%
4	0.88	80.4	1%	50%	1%	1%
4	0.88	66.5	2%	2%	2%	2%
5	0.88	86.8	4%	4%	4%	4%
5	0.88	69.7	3%	3%	3%	3%
2	0.78	77.9	0%	0%	0%	0%
3	0.78	77.9	2%	0%	2%	0%
4	0.78	77.9	2%	4%	2%	51%
4	0.78	72.2	0%	0%	0%	0%
4	0.78	59.4	1%	1%	1%	1%
5	0.78	77.9	0%	0%	0%	0%
5	0.78	67	0%	0%	0%	0%
2	0.71	71.7	0%	0%	0%	0%
3	0.71	71.7	2%	0%	2%	0%
4	0.71	71.7	2%	4%	2%	6%
4	0.71	66.4	0%	0%	0%	0%
4	0.71	54.5	1%	1%	1%	1%
5	0.71	71.7	0%	0%	0%	0%
5	0.71	61.6	0%	0%	0%	0%

Source: Navigant analysis

Table 55. Initial and New Ballast 2015 Market Share

Lamp Type	Initial Ballast	New Ballast
T12	86%	14%
T8	64%	36%

Source: Navigant analysis